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HANDBOOK OF  
VERTEBRATE DISSECTION  
PART III.  
HOW TO DISSECT A RODENT

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H. NEWELL MARTIN  
AND  
W. A. MOALE

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# HANDBOOK

OF

## VERTEBRATE DISSECTION.

BY

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AND

WILLIAM A. MOALE, M.D. -

PART III.  
*HOW TO DISSECT A RODENT.*

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## P R E F A C E.

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THIS little book, like its predecessors in the same series, is designed for use at the dissecting-table, and not to take the place of attendance on lectures or the study of a text-book of comparative anatomy. We have assumed that the teacher or text-book will supply such references to original sources as it is desirable that students should be acquainted with, and have accordingly entirely omitted all such. As some critics of Parts I. and II. appear to have thought that such omission made it possible that the discoveries of others should be credited to us, we desire to state that, so far as we know, no new fact in mammalian or rat anatomy is to be found in the following pages, nor any novel method of dissecting. What we have attempted is to make it easy for a student to learn practically what a mammal, regarded from a morphological standpoint, is. In pursuance of this plan, details which are diagnostic or generally characteristic of mammalia have been treated with more fulness than generic or specific peculiarities.

From a certain point of view the title of the book

may seem a little absurd. The methods suitable for the satisfactory dissection of a rat would assuredly be quite inapplicable to the practical study of the anatomy of a whale or an elephant. But to the student who dissects, not to learn the detailed anatomy of any one species, but the common structural characters of a class, it matters little which animal is selected if it be readily obtainable and fairly typical. A book giving directions for the dissection of any such mammalian species may be fairly entitled "How to Dissect a Mammal."

Our choice of the rat was largely determined by its abundance and wide distribution, and the fact that no one is likely to object to the killing of as many rats as can be caught. The larger size of dogs and cats would have been to a certain extent an advantage ; but domesticated animals are not to be easily obtained in such numbers as to provide a liberal supply of material for students. Further, we feel sure that he who aspires to become a comparative anatomist, and yet finds a rat too small for the observation of all the main facts in its structure, has mistaken his vocation.

BALTIMORE, January 10, 1884.

## CONTENTS.

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|  | PAGE |
|--|------|
| ZOOLOGICAL POSITION OF THE COMMON BROWN RAT, . . . . . | 169  |
| ANATOMY OF THE BROWN RAT, . . . . .                    | 173  |
| INDEX, . . . . .                                       | 241  |

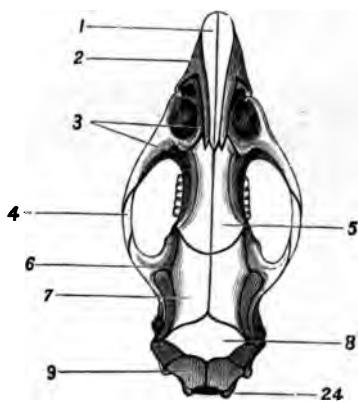


## DESCRIPTION OF THE FIGURES.

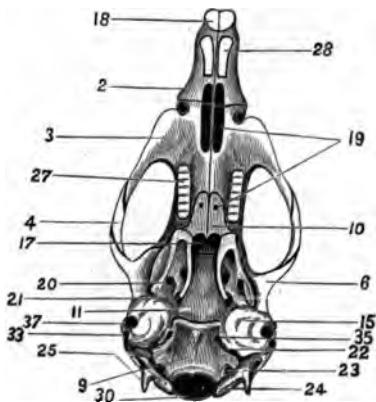
FIG. 1, represents the roof of the skull ; FIG. 2, its base ; FIG. 3, the skull as seen from the left side ; FIG. 4, the inner side of the right half ; FIG. 5, its posterior aspect ; FIG. 6, is a diagram showing the relative positions of the bones of the skull.

The references to the figures of the skull are as follows : 1, the nasals ; 2, the premaxillæ ; 3, the maxillæ ; 4, the jugal ; 5, the frontal ; 6, the squamosal ; 7, the parietal ; 8, the inter-parietal ; 9, the occipital ; 10, the palatine ; 11, the sphenoid ; 12, the presphenoid ; 13, the ethmoid ; 14, the lachrymal ; 15, the tympanic bulla ; 16, the periotic capsule ; 17, the opening of the posterior nares ; 18, the opening of the left anterior naris ; 19, the prepalatine and postpalatine foramina ; 20, the foramen for the inferior maxillary division of fifth nerve ; 21, the jugular foramen ; 22, the foramen lacerum posterius ; 23, the condyloid foramen ; 24, the occipital condyle ; 25, the paroccipital process ; 26, superior process of occipital ; 27, the molars ; 28, the incisors ; 29, the infra-orbital fissure ; 30, the foramen magnum ; 31, the vomer ; 32, the optic foramen ; 33, the foramen for the seventh nerve ; 34, cavity for flocculus ; 35, the carotid foramen ; 36, foramen between the pterygoid processes ; 37, the opening of the external auditory meatus ; 38, foramen for nasal branch of the fifth nerve.

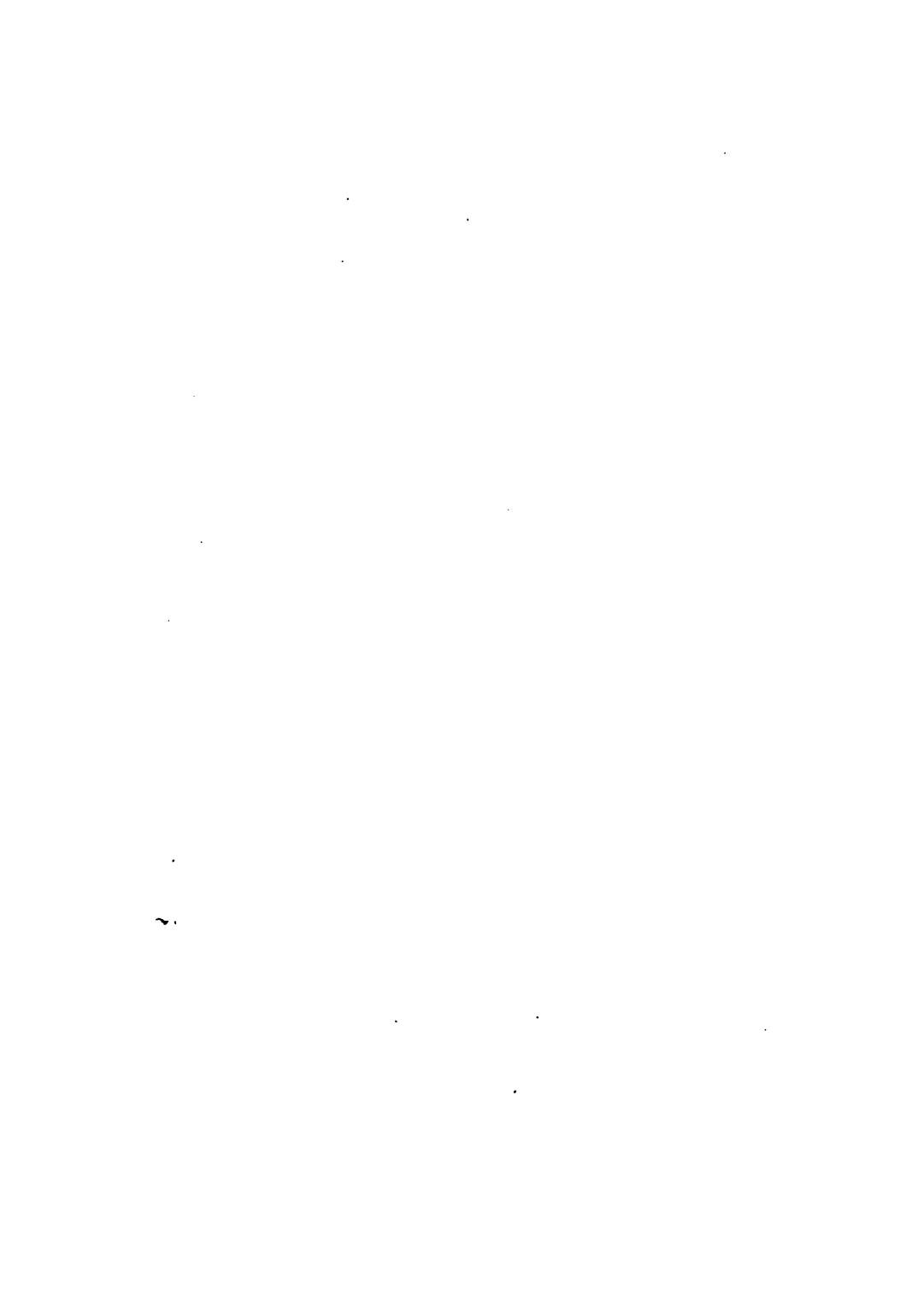




**Figure 1.**



**Figure 2.**



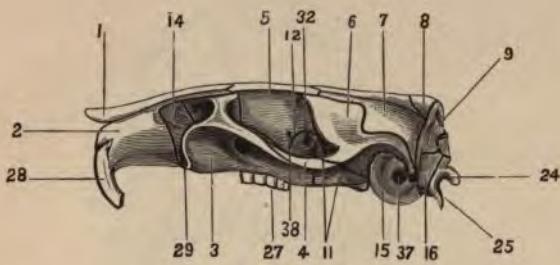


Figure 3.

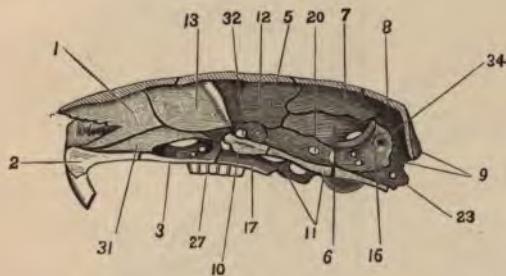


Figure 4.

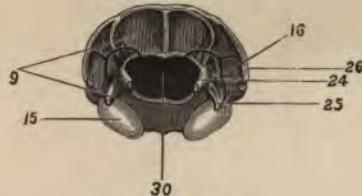


Figure 5.



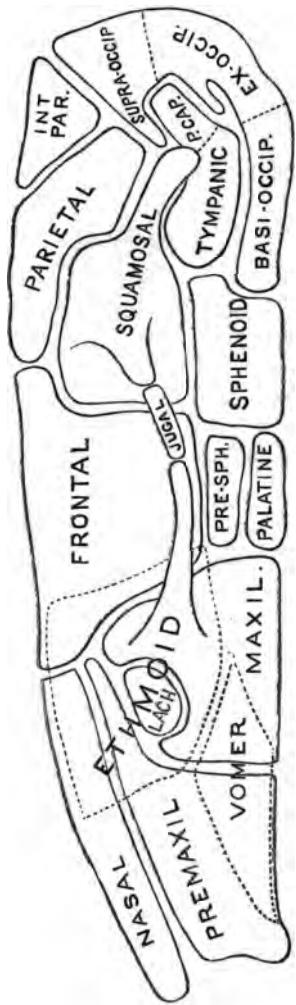


Figure 6.



## ZOOLOGICAL POSITION OF THE COMMON BROWN RAT.

SUBKINGDOM, **Vertebrata**. CLASS, **Mammalia**. SUBCLASS,  
**Monodelphia**. ORDER, **Rodentia**. GENUS, **Mus**.  
SPECIES, **decumanus**.

### Characters of the **Mammalia**.\*

1. Always possess an epidermic exo-skeleton in the form of hairs.
2. The vertebræ are ossified, and (except in the ornithodelphia) their centra have terminal epiphyses.
3. All the segments of the brain-case are completely ossified. No distinct parasphenoid exists in the adult. The proötic ossifies, and unites with the epiotic and opisthotic before these coalesce with any other bone.
4. There are always two occipital condyles, and the basi-occipital is well ossified.
5. The mandible is always present, and each ramus consists (at any rate in the adult) of a single membrane bone, which articulates with the squamosal. The quadrate bone and the supra-stapedial element of the hyoidian arch are converted into a malleus and an incus, so that with the stapes there are at fewest three *ossicula auditus*.
6. The alimentary canal may or may not terminate

---

\* Huxley.

in a cloaca. When it does not, the rectum opens behind the genito-urinary organs.

7. The heart is quadrilocular. Some of the blood-corpuscles are red and non-nucleated.

8. There is only one aortic arch, which lies on the left side.

9. Respiration is never effected by means of branchiæ; but, after birth, is performed by lungs.

10. There is a complete diaphragm.

11. The Wolffian bodies are replaced by permanent kidneys.

12. The cerebral hemispheres are united by a corpus callosum.

13. The reproductive organs may, or may not, open into a cloaca. The oviduct is a Fallopian tube.

14. The embryo has an amnion and allantois.

15. Mammary glands supply the young with nourishment.

#### Characters of Subclass Monodelphia.

1. The *os odontoideum* very soon anchyloses with the second cervical vertebra, and becomes thus an "odontoid process."

2. The cervical ribs very soon inseparably join their vertebræ.

3. The coracoid is a mere process of the scapula, and there is no epicoracoid. Clavicles when present do not articulate with an interclavicle.

4. The acetabula are imperforate.

5. The cochlea is coiled spirally.

6. The reproductive and urinary apertures usually open quite separately from the rectum. The ureters always open into the bladder.

7. The testes may, or may not, descend into a scrotum ; when the latter forms a distinct sac it lies on the sides of, or behind the penis, but not in front of it. The cystic urethra is continuous with the penial.

8. The ova are small, and the mouths of the Fallopian tubes fimbriated. The vagina is a single tube, rarely partially divided by a longitudinal septum. The mammary glands have distinct teats, and are not covered by the cremaster muscle.

9. The allantois is well developed, and gives rise to a placenta. The young are born of relatively large size and active.

There are two main groups of monodelphia, deciduate and non-deciduate. The rat belongs to the former, because at birth a part of the uterine mucous membrane of the mother is thrown off along with the foetal portion of the placenta.

#### Characters of the Rodentia.

1. There are no canine teeth. The lower jaw never contains more than two incisors, and these continue to grow throughout life. Except in one family, there is only one tooth in each premaxilla ; in the hares and rabbits there is a second small incisor posterior to each of these.

2. The molars are two to six in number in each half of the upper jaw ; and two to five in each half of the lower. They may form roots or may continue to grow through life. When there are more than three molars that one which precedes the three hindermost is a *pre-molar*—that is, has replaced a milk tooth.

3. The premaxillæ are always large. The orbits are never shut off by bone from the temporal fossæ. The condyle of the mandible is generally elongated antero-posteriorly.

4. The cæcum is large, except in the dormice (*Myoxinæ*).

5. The cerebral hemispheres always leave much of the cerebellum uncovered when the brain is viewed on its dorsal aspect ; they are smooth or but very slightly convoluted. The *corpus callosum* is well developed.

6. Other characters of most of the Rodentia are the following : nineteen dorso-lumbar vertebræ ; a large interparietal ossification ; a short jugal bone ; clavicles present ; a ninth bone in the carpus, between the proximal and distal series ; five digits, with small claws ; the testes do not leave the abdomen, but come down into the groin in the breeding season ; *vesiculæ seminales* and prostate glands are present.

## THE ANATOMY OF THE BROWN RAT.

(*Mus decumanus.*)

1. **General External Characters.**—Taking a recently killed rat \* note :—

- a. Its general form, and the main divisions of its body externally recognizable : head, neck, trunk, tail, and limbs.
- b. *The hair* covering most of the body ; dark brown on the back, where it is longest and stiffest about the middle line. Toward the flanks the hair becomes lighter, shading off to a dirty gray on the ventral aspect, where it is fine and soft. Certain regions of the skin are bare, namely, the palmar and planter surfaces of manus and pes, and the tip of the snout (*muffle*). At some parts there are groups of long and specially stiff tactile hairs (*vibrissæ*). They will be found on the sides of the snout, where they are especially well developed ; also farther back on the side of the head ; beneath the lower jaw ; and on the ventral aspects of the forearms. On the dorsum of manus and pes, and on the external ears, the hairs are very short, and do not conceal

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\* Rats are most conveniently killed by chloroform ; drowning is a cheaper method, but spoils the hair. Those animals wanted only for examination of the internal organs may be drowned.

the skin. The *tail*, which is about as long as the trunk, is covered by imbricated scales, and from beneath the posterior margins of these short stiff hairs project.

## 2. The Openings on the Surface of the Body.

- a. The *mouth opening* is surrounded by large, soft, movable lips, which can be retracted so as to fully uncover the incisor teeth. This is facilitated by the deep cleft in the upper lip, from which a groove passes up between the nasal openings.
- b. The paired *external nares*, opening on the muffle.
- c. Protecting the small black eyes are movable upper and lower lids, fringed with eyelashes (*cilia*), and meeting in front and behind at the *outer* and *inner canthi* respectively. On separating the eyelids, the *membrana nictitans* will be found ; spread it out and note that it does not completely cover the front of the eyeball. At the inner canthus there will be seen a slight pigmented elevation (*carunculus*) of the conjunctival mucous membrane ; above and below it the openings of the *lachrymal canal* can be made out with the aid of a pocket lens, and a fine bristle passed into them.
- d. The prominent *pinna* on each side surrounds the opening of the *external auditory meatus*.
- e. The posterior opening of the alimentary canal, the *anus*, will be found under the root of the tail.
- f. Ventral and anterior to the anus there will be seen, in males, the *penis*, covered by a loose

sheath of skin, *the prepuce*. On pushing this off the end of the penis, the *genito-urinary aperture* at the end of the latter will be found. If the animal was in rut when killed, the large *testes* can be felt inside a prominent fold of the skin (*scrotum*) between the anus and penis.

- g. If the animal be a female, the *opening of the vagina* will be seen ventral to the anus.
- h. In front of the vagina is the *clitoris*, covered by a small prepuce. At the root of the clitoris, on its posterior side, will be found the *opening of the urethra*.
- i. On the female will also be seen the *teats*, six on each side, three *pectoral* and three *abdominal*. At the tip of each teat is a single small opening.

**3. The fore limb** is short and small, terminating in a *manus* having five *digits*, each furnished with a curved claw; except the thumb, which is rudimentary and bears a *flattened nail*. On the palm are fleshy pads.

**4. The hind limb** is longer and much more powerful than the fore limb, the *pes* being specially well developed. The *digits of the pes* are five in number, furnished with claws; its plantar surface hairless, and marked by fleshy pads similar to those of the manus.

#### The Bony and Cartilaginous Skeleton.

5. Open the belly of a rat, and remove the viscera of the abdominal cavity. Thoroughly boil the remainder of the body; then carefully clean away the soft parts from the bones and cartilages. Using the skeleton

thus prepared, and an articulated mounted specimen, note the following points :

6. The general arrangement of the skeleton ; skull, spinal column, ribs, and sternum, limb arches and limbs. On the articulated mounted specimen, note :

7. The general form and relative size of the skull, and the bony ridges on it, above and behind, for the attachment of muscles ; also its sutures ; then remove the lower jaw from the freshly prepared skeleton, and observe on the **base of the skull**:

- a. A short way behind the incisor teeth the large, paired, antero-posteriorly elongated *prepalatine foramina* (Fig. 2, 19).
- b. Posteriorly, near the alveolar portion of the superior maxillæ, a second pair of small foramina (*posterior palatine foramina* (Fig. 2, 19).
- c. Farther back in the median line the posterior common opening of the nasal passages, bounded anteriorly by the palate bones and externally by the pterygoid processes of the sphenoid bone (Fig. 2, 17).
- d. Within the posterior nasal opening, through an unossified space in its lateral wall, note the *foramen lacerum anterius*, with which is blended the *foramen rotundum*. Through this opening the first and second divisions of the fifth nerve (127, a, and b) escape from the cranial cavity.
- e. Between the pterygoid processes is a large foramen.
- f. Dorsal to the posterior prolongation of the

external pterygoid process the *foramen ovale*, through which passes the third division of the fifth nerve (127, c).

- g. Near the posterior extremity of internal pterygoid process the *jugular foramen* (Fig. 2, 21).
- h. The *tympanic bulla*, a relatively large, thin-walled projection on each side of the posterior part of the base of the skull, pierced at its inner and anterior extremity by the bony *Eustachian canal*, and presenting externally the opening of the external auditory meatus.
- i. Between the internal borders of the tympanic bullæ and the basioccipital the small opening of the *carotid canal* (Fig. 2, 35).
- j. Opposite the posterior border of each bulla the *foramen lacerum posterius*, which gives passage to the ninth (*glosso-pharyngeal*) (131), tenth (*pneumogastric*) (129), and eleventh (*spinal accessory*) (132) cranial nerves.
- k. The *occipital condyles* bounding ventro-laterally the *foramen magnum*; and anterior to them the *condyloid foramina* for the *twelfth pair (hypoglossal)* of cranial nerves (130).
- l. The *foramen for the seventh nerve (facial)* (128), dorsal to the outer side of the tympanic bulla, and posterior to the bony portion of the external auditory meatus.

#### 8. On the Side of the Skull note :

- a. The *infraorbital fissure* in front of the anterior root of the zygomatic arch, through which the infraorbital branch of the fifth nerve (Fig. 3, 29) reaches the snout.

- b. The great *orbito-temporal fossa* bounded externally by the *zygomatic arch*.
- c. On the inner wall of the orbital fossa the *optic foramen*, and ventral to it, in part, the *anterior lacerated foramen*.
- d. Dorsal and anterior to the optic foramen, and about the middle of the inner orbital wall, the small foramen for the nasal branch of the fifth nerve (143, 1).

9. Boil the skull for fifteen minutes or half an hour, and then remove the bones which compose it in the following order, noting carefully their relative positions and articulations :

- a. The *nasals*, a pair of long flat bones, which form the roof of the nasal cavity. From the ventral surface of each bone near its external margin projects a large, somewhat convoluted process, which forms part of the bony laminæ subdividing the nasal passages. Along the median line the nasal bones meet; posteriorly they articulate with the frontals, externally with the premaxillæ.
- b. The *premaxillæ*, a pair of large bones forming with the nasals the extremity of the snout. Anteriorly, each premaxilla bears one of the large upper incisors, which when removed from its alveolus is seen to form a semicircle. Note also the vertical plate of bone which projects from the margin of its ventral border and forms part of the partition between the nares. The bone has a long stout process, projecting from its dorsal border, and directed

posteriorly, which separates the nasal and maxillary bones ; its inner surface presents delicate convoluted plates, which, like those of the nasal bones, reach into the nasal passages. The premaxillæ articulate posteriorly with the frontals, externally with the maxillæ, internally with the nasals.

- c. The *maxilla*, an irregular bone on each side posterior to the premaxilla. Projecting from it, outward and upward, is a bony plate, to the inner side of which lies the infraorbital fissure. From the upper end of this plate two processes arise ; the shorter is directed inward, and articulates with the premaxilla and frontal bones, and has attached to its posterior margin a small knob of bone, which separates from it on maceration. The larger, directed outward and backward, forms the anterior half of the zygomatic arch. On the inner side of the infraorbital fissure the maxilla is unossified, allowing the ethmoid to be seen. Ventrally the *alveolar*, and *palate processes* form the bulk of the bone ; the latter, however, anteriorly is almost entirely wanting, owing to the great size of the prepalatine foramen. The alveolar process carries the three upper molar teeth. Anteriorly the maxilla articulates with the premaxilla, internally and superiorly with the orbital process of the frontal bone, ventrally and internally by its alveolar portion with the palatine bone of the same side, and by its palatine process, along the median line, with its fellow.

- d. The *jugal* is placed about the middle of the zygomatic arch, and is a small bar of bone articulating anteriorly with the maxilla, and posteriorly with the zygomatic process of the squamosal.
- e. The *palatines* lie posterior to the maxillæ on the base of the skull. From their ventral margins a pair of horizontal plates are given off, which, meeting along the median line, form the posterior third of the hard palate, and help to bound the opening of the posterior nares. Dorsally, the bones articulate with the wings of the presphenoid (*orbito-sphenoids*), and posteriorly with the pterygoid processes of the sphenoid.
- f. The *vomer*, lying in the median line between the nares, is best exposed by the removal of the premaxillæ and palatine bones, or in a longitudinal section of the skull. It is placed immediately below the perpendicular plate of the ethmoid, and articulates ventrally with the premaxillæ and with the inner borders of the palatine plates of the maxillæ. It is a mere scale of bone, and is apt to be removed in cleaning the skull, or removing the premaxilla.
- g. The *lachrymal* bone lies internal to the infra-orbital fissure, articulating with the premaxillæ in front, the orbital processes of frontal and maxilla behind, and the ethmoid internally.
- h. After the removal of the bones already described, the *ethmoid* forms the anterior part of

the remaining portion of the skull, overlapped by the anterior half of the frontals. Seize the middle plate of the ethmoid with the forceps, and draw the bone out of the cavity in which it is set. After its removal the front of the cranial cavity will be left open. The ethmoid is composed of a thin, perpendicular plate of bone (*ethmoid proper*) having on either side, and connected with its dorsal edge by a bony bridge, a mass of thin, convoluted, bony plates (*lateral masses of the ethmoid or prefrontals*). All of these spring posteriorly from the cribriform plate, which in its natural position is exposed inside the skull, where it presents along the median line a slight ridge (*crista galli*); on each side of this it is pierced by numerous small foramina, through which pass the filaments of the olfactory nerve. Dorsally the ethmoid articulates with the frontals, laterally with the lachrymals, and anteriorly with the *internasal cartilaginous septum* and the vomer.

- i. The *frontals* form the anterior portion of the roof of the cranial cavity, and a large part of the inner wall of the orbit. Anteriorly they articulate with the nasals, premaxillæ, and maxillæ, posteriorly with the parietals and squamosals, and ventrally with the wings of the sphenoid (*alisphenoids*) and presphenoid (*orbitosphenoids*). Their under surfaces in front are in contact with the ethmoid.
- j. The *sphenoid* is composed of a basal portion (*basisphenoid*), broader posteriorly than anteriorly, from the sides of which spring the *ali-*

*sphenoids*, curving outward and dorsally, and forming part of the inner wall of the orbito-temporal fossa. From the root of each alisphenoid springs a pair of irregular *pterygoid processes*, the inner of which are the homologues of the pterygoid bones of lower animals. Four foramina are found in the sphenoid, three of which have been already described (*i, e, f, g*) ; the fourth, seen anterior to the foramen ovale and dorsal to the external pterygoid process, transmits a small nerve. The sphenoid articulates anteriorly with the presphenoid and orbitosphenoids, posteriorly with the basioccipital, and by its wings with the squamosals and frontals.

- k.* The *presphenoid*, which often comes away with one of the frontals, is composed of a basal portion, and pair of small wings (*orbitosphenoids*), perforated, where they join the former, by the *optic foramina*. Posteriorly it articulates with the sphenoid, and externally with the frontals, while its basal portion is continuous anteriorly with a rod or plate of cartilage, which is continuous with the internasal cartilage.
- l.* The *parietals* form the middle of the roof of the skull, and are prolonged downward to form part of its sides. Along the median line they are united by the *sagittal suture*, and articulate anteriorly with the frontals by the *coronal suture*; ventrally and externally with the squamosals, by which they are in part overlapped; posteriorly with the interparietal bone; and external to it with the supra-occipital.

- m. The *squamosal* is a flat bone placed on either side of the cranium in front of the auditory capsule. Anteriorly it is much expanded, and has projecting from it a large process (*zygomatic*), which articulates with the *jugal*, and completes the zygomatic arch; posteriorly it is prolonged, and has projecting from its inferior angle the *post-tympanic hook*, a process which partly laps over the auditory capsule, and helps to retain it in position. Superiorly it articulates with the frontal and parietal, anteriorly with the frontal and wing of the sphenoid, ventrally with the wing of the sphenoid, and posteriorly with the exoccipital portion of the occipital bone.
- n. Placed between the parietals in front and the occipital behind is the *interparietal*.
- o. The *occipital*, which is formed by the coalescence at an early period of the supra-, basi-, and ex-occipitals, forms the posterior segment of the brain-case, and surrounds the *foramen magnum*. Note the large *occipital condyles*, one on either side, and external to these the long curved *par-occipital processes*. From the external superior angles of the bone a second pair of processes project ventrally, between which and the par-occipital processes the external margins of the bone are deeply excavated to receive the auditory capsules. Anterior to the occipital condyles, note the *anterior condyloid foramina* through which pass the *twelfth (hypoglossal)* nerves. The basilar portion of the occipital completes the floor of the

skull ; posteriorly it is broad, but anteriorly it narrows to articulate with the basisphenoid.

- p. The *periotic capsule*, composed of the coalesced proötic, epiotic, and opisthotic, appears on the exterior of the skull, where it is inserted into the gap in the external border of the occipital bone, and abuts against its basal portion. On its inner wall note the projections formed by the vestibule and semicircular canals.
- q. The *tympanic bone*, which presents an opening on the side of the skull, within which, in the fresh state, is seen the tympanic membrane, is greatly dilated to form a large bulla concealing the petrous portion of the periotic.

10. The lower jaw is composed of two laterally flattened bones meeting anteriorly at an acute angle to form the *symphysis menti*. On it note :

- a. The *body* bearing posteriorly, the lower molar teeth, and anteriorly the lower incisors, between which is a toothless area, the *diastema*.
- b. Posterior to the insertion of the molars the *rami* of the jaw, which are continued backward in the same line as its body.
- c. Terminating the rami posteriorly the *condyloid processes*, bearing convex articular surfaces elongated antero-posteriorly.
- d. Springing from the upper margin of the rami and curving posteriorly, the *coronoid processes*.
- e. Projecting from the inferior border of the jaw, where rami and body meet, a pair of large processes affording attachment to the mus-

cles of mastication. On the inner aspect of each of these processes, close to the angle of the jaw, is a small foramen.

- f. At the base of each condyloid process, on its inner side, the *dental foramen*, and anteriorly in front of the molar teeth the *mental foramen*; these mark the extremities of the *dental canal*.

11. **The hyoid** is a delicate, U-shaped bone, having a narrow flattened body placed transversely to the axis of the neck; from the outer ends of the body project anteriorly a pair of short processes (*anterior cornua*), and posteriorly a pair of slender, much larger processes, curving dorsally and externally (*posterior cornua*).

12. **The cervical vertebrae** are seven in number. Take the fifth for special study, and note :

- a. Its *neural arch* surmounted by a rudimentary *spine*.
- b. The *centrum*, broad and flat, and presenting anteriorly and posteriorly roughened surfaces, to which were attached *terminal epiphyses*, usually removed with the fibrocartilages in cleaning the bone.
- c. Springing from the vertebra on either side, at the junction of neural arch and centrum, a long *transverse process*, directed outward and backward, and pierced at its base by the vertebral foramen. The bony bar closing this foramen ventrally represents a *cervical rib*, which has fused with the vertebra.

- d. The *pre-* and *post-zygopophyses*, the first being much the larger, bearing articular facets; those of the former looking inward and dorsally, and of the latter downward and outward.
  - e. The narrowed part (*pedicle*) of the neural arch where it joins the centrum. Between the pedicles of adjacent vertebrae are left apertures, the *intervertebral foramina*, through which the spinal nerves escape from the neural canal.
13. The above description will apply to all the cervical vertebrae except the following:
- a. The *atlas*, or first cervical vertebra, a ring-shaped bone, bearing ventrally and dorsally a small spine, and laterally a pair of wing-like transverse processes pierced at their bases by two canals; one running from before backward for the vertebral vessels, and the other transversely for the first cervical nerve. Anteriorly it presents on either side a cup-shaped articular facet for articulation with the condyles of the skull (9, o), and posteriorly a pair of small post-zygopophyses, which, together with the transverse bar forming the ventral portion of the bone, bear a surface by which it articulates with the axis.
  - b. Stretching across the space encircled by the bone, which it divides into a ventral and dorsal portion, the *transverse ligament* will be seen, unless it has been removed in cleaning the skeleton.

- c. **The axis**, or second cervical vertebra; on it note the *odontoid process* attached to the anterior end of its centrum, and, normally, fitting into the ventral division of the ring of the atlas.
- d. Surmounting the neural arch is a large spine, and anteriorly on either side of the odontoid process, as well as on its ventral sides, a surface for articulation with the atlas. Posteriorly the vertebra bears a pair of small postzygapophyses.
- e. The transverse processes of the sixth cervical vertebræ are large and bifurcated at their extremities, and those of the seventh abut against the tubercula of the first ribs. The centrum of the seventh cervical vertebra is marked by a demi-facet for the head of the first rib; this vertebra has also no vertebral foramen.

**14.** There are thirteen **dorsal vertebræ**. Examine one from the middle of this region, and note :

- a. Its cylindrical centrum marked anteriorly and posteriorly on each side by a demi-facet for articulation with the head of a rib.
- b. The neural arch emarginated anteriorly, and produced posteriorly so as to cover the deficiency of the neural arch of the succeeding vertebra.
- c. Projecting upward and backward from the summit of the neural arch a long, stout *spinous process*; and from its sides a pair of *transverse processes*, presenting ventrally articular facets for the capitula of the corresponding ribs.

- d. The spine of the second dorsal vertebra is noticeable for its great size, and the enlargement of its extremity. The spines of the eleventh, twelfth, and thirteenth are directed forward.

15. Following the dorsal are the six large **lumbar vertebræ**. On them note :

- a. The neural arches emarginated anteriorly, and projecting posteriorly beyond their centra.
- b. The large flattened spinous processes inclined forward.
- c. The great pre- and post-zygapophyses ; the former enlarged dorsally to form a series of *metapophyses*, which may be traced into the posterior dorsal region.
- d. Their transverse processes becoming greatly developed as we pass backward, and directed ventrally and forward.
- e. Springing from the roots of the transverse processes of all the lumbar vertebræ, except the last, and from the three posterior dorsal vertebræ, and directed caudally, a series of *anapophyses*.
- f. The centra, long and cylindrical, and showing ventrally rudiments of spines.

16. There are three **sacral vertebræ** with broad transverse processes flattened dorso-ventrally, and united at their outer ends ; those of the first and second abut against the ilia.

17. Succeeding the sacral, are the **caudal vertebræ**, about twenty-five in number. Note :

- a. That the anterior ones have metapophyses, zygapophyses, transverse, and spinous processes, which gradually disappear as the vertebræ become smaller.
- b. That the neural canal becoming small in the anterior caudal region, soon altogether disappears, each vertebra then consisting only of a cylindrical centrum constricted in the middle.
- c. Projecting ventrally from the centra in the anterior part of the tail are pairs of spines, between which the main caudal vessels run.

**18.** The ribs are twenty-six in number. The seven anterior on each side (*vertebro-sternal*) articulate through the intervention of costal cartilages with the sternum. The succeeding three (*vertebro-costal*) have their cartilages attached ventrally to the cartilage of the last *vertebro-sternal* rib ; and the last three (*vertebral*) have their ventral ends free.

**19.** Examine the sixth rib, noting :

- a. That it is a flattened bar, composed of two portions, a vertebral, and a sternal, the latter cartilaginous.
- b. The curve of the rib, and its peculiar twist, which causes the vertebral half to be flattened antero-posteriorly, and the sternal portion dorso-ventrally.
- c. On the vertebral portion, the *capitulum*, by which the rib articulates with two adjoining dorsal vertebræ.
- d. External to the capitulum, the *tuberculum*, having a facet for articulation with the transverse

process of the more posterior of the vertebrae with which the head articulates.

- e. The *angle of the rib*, where its curve rather abruptly changes, marked by a bony eminence.

**20. The sternum** is composed of six segments (*sterne-bræ*). The five anterior are bony; the first (*manubrium*) is larger than the others, expanded anteriorly, keeled ventrally, and has attached to it the two first pairs of vertebro-sternal ribs. The third, fourth, and fifth pairs of vertebro-sternal ribs are articulated with the sternum at the points where its posterior segments meet one another, and the sixth and seventh pairs are joined to the fifth segment near its posterior end. The sixth segment of the sternum (*xiphisternum*) terminates in a round plate of cartilage.

**21. The shoulder girdle** is formed by two bones on each side; the *scapula* and *clavicle*.

**22. The scapula** is a triangular bone overlying the ribs dorso-laterally. At its anterior angle note the *glenoid cavity* for articulation with the head of the humerus, and above this the coracoid process directed ventrally and inward. Running along the middle of the dorsum of the scapula a thin ridge (*spine*) terminating anteriorly in a broad flat process, the *acromion*, which overhangs the glenoid cavity. Above and below the spine of the scapula are the *supra-*, and *infra-spinous fossæ*, the latter bounded below by a second prominent ridge forming the lower margin of the bone.

**23. The clavicle** is a thin bar of bone articulating

with the manubrium of the sternum internally, and with the coracoid and acromion processes of the scapula externally.

**24. The Bones of the Fore Limb.**—The humerus is a relatively short bone, expanded at its proximal end, and bearing a rounded head placed at an obtuse angle to the shaft; by this it articulates with the scapula. The shaft of the bone toward its distal end is flattened dorso-ventrally, and expanded as it passes into the *external* and *internal condyles*, between which is the articular surface for the ulna and radius. A large bony ridge (*greater tuberosity*) projects ventrally from the proximal half of the shaft.

**25.** The bones of the forearm, *ulna* and *radius*, though ankylosed in a position of pronation to form a single bone, are readily distinguishable. The former is much the stouter and longer; its superior extremity projecting beyond the radius forms the *olecranon process*; distal to which is the *sigmoid notch*, on which fits the pulley-like articular surface of the humerus. The *radius* is closely applied to the anterior border of the ulna, and with its small expanded head helps to deepen the sigmoid notch. Distally both bones are expanded and articulate with the carpus.

**26. The carpus** is composed of the following bones :

- a. A large bone articulating with the radius, and formed by the coalescence of the *radiale*, and *intermediale*, which answer to the *scaphoid*, and *semilunar* of human anatomy.
- b. The *ulnare* (*cuneiform* of human anatomy) hav-

ing ankylosed to it the *pisiform*, a sesamoid bone.

- c. The *carpalia*, four in number and, beginning on the outer side, corresponding respectively to the *trapezium*, *trapezoid*, *os magnum*, and *unciform* of man; they form the distal row of bones, and support the *metacarpals*; the fourth articulates with the metacarpals of the fourth and fifth digits, *annularis* and *minimus*.
- d. Placed between the bones of the first row and the middle carpalia is a triangular bone, the *centrale*.
- e. Articulated to the *radiale* is a *sesamoid bone*, having a curved form, and serving with the *pisiform* to deepen the groove for the flexor tendons of the hand.

**27.** There are five *metacarpal bones*; the third and fourth being the longest, while those for the *pollex* and *digitor minimus* are greatly shortened.

**28.** The *phalanges* are three for each digit, except the *pollex*, which has only two. The terminal phalanges are furnished with claws, that of the pollex being flattened so as to resemble a nail.

**29.** The *pelvic girdle* is made up of three bones, the *ilium*, *ischium*, and *os pubis* on each side, firmly ankylosed together, and united ventrally by fibrous tissue in the *symphysis pubis*.

**30.** The *ilium* is an elongated bone expanded anteriorly, and abuts against the transverse processes of the

two anterior sacral vertebræ. Posteriorly it is constricted and rounded, and enters into the formation of the *acetabulum*.

**31.** The *ischium* is a triangular bone, having a concave internal, and a convex external surface. Anteriorly it forms part of the *acetabulum*, ventrally it unites with the descending ramus of the pubis, and posteriorly is thickened to form the *tuberosity of the ischium*. Between the ischium and pubis is the large *obturator foramen*.

**32.** The *pubis* by its dorsal end contributes to form the *acetabulum*; ventrally it unites with its fellow at the *symphysis pubis*; by its descending ramus it fuses with the ischium.

**33.** Examine the *acetabulum*, and note that it is a bony cup presenting an articular surface for the head of the femur; on its median side it is deeply excavated to form a pit, from which a groove passes outward and ventrally, causing a gap in its wall.

**34. The Bones of the Hind Limb.**—The *femur* has a long, thick shaft flattened antero-posteriorly, and terminating above in a large bony process, the *greater trochanter*, ventral to which is the *lesser trochanter*. The proximal half of the outer border of the bone bears a great bony ridge, the *third trochanter*. Springing perpendicularly from the shaft, greater and lesser trochanters is the narrow neck, which bears the rounded head of the bone. The distal extremity of the bone is expanded into an *external* and *internal condyle*; these pre-

sent surfaces for articulation with the head of the tibia. Anteriorly is seen a smooth groove in which the patella glides, and between the condyles a deep depression, the *intercondyloid notch*.

35. The *tibia* is a stout bone bowed anteriorly. Its shaft is triangular, and presents in front a sharp ridge. Proximally it is greatly expanded to form a head, and distally is prolonged to form the inner malleolus.

36. The *fibula*, a slender bone, lies behind the tibia. Its expanded proximal end is attached by ligament to that of the tibia; the distal end of the bone is firmly ankylosed to the lower third of the tibia, beyond which it projects to form the *external malleolus*, between which and a corresponding process of the tibia (*internal malleolus*) the astragalus plays.

37. In front of the knee-joint is the *patella*, a sesamoid bone developed in the tendon of the chief extensor muscles of the leg, which is attached to the head of the tibia. Posterior to the same joint are two other sesamoid bones lying behind the condyles of the femur.

38. The *tarsus* is composed of

- a. The *astragalus (intermediale)*, presenting a deeply grooved articular surface for tibia and fibula dorsally, and a second articular surface ventrally for the *os calcis*. Projecting anteriorly is a large process, which articulates with the scaphoid, and a small bone on the inside of the foot (*tibiale*).
- b. The *os calcis or calcaneum (fibulare)* is a stout

bone supporting the heel, and projecting posteriorly beyond the astragalus. Distally it expands, and articulates with the scaphoid, cuboid, and astragalus.

- c. The *scaphoid* or *navicular bone (centrale)* is placed between the astragalus on its proximal side, and the three cuneiform bones distally.
- d. The *cuboid (fourth and fifth tarsalia)* is internal to the navicular, and articulates with the os calcis and the fourth and fifth metatarsals.
- e. The three *cuneiform bones (first, second, and third tarsalia)* articulate with the scaphoid, and carry the corresponding metatarsal bones. The innermost is much the largest, and articulates by its proximal end with the tibiale.

**39.** There are five **metatarsal bones**; the first, that of the great toe, and fifth, that of the little toe, being smaller than the others. The fifth sends a process backward on the inner side of the cuboid.

**40.** The *digitis* have each three *phalanges*, except the first or *hallux*, which has two. The terminal phalanges are furnished with short curved claws.

**41.** The *teeth* of the rat are an *incisor* and three *molars* in each half of each jaw. The dental formula is, therefore, *i. 1=1, c. 0=0, p. m. 8=8, m. 3=3*.

- a. Having noted the size, position, and form of the teeth, especially the chisel-shaped edges of the incisors, due to the thick layer of enamel on the anterior surface of each, which makes it wear away less fast than the posterior

surface, extract one of the upper incisors of a recent specimen, breaking away with pincers the bone on its outer side.

- b.* The whole tooth will be seen to form almost a semicircle, and its embedded portion to be considerably longer than the exposed. The innermost end is imperfectly calcified, and presents a large opening, through which the pulp enters the tooth cavity.
- c.* Break away the bone on the outer side of one of the lower incisors, so as to expose the tooth *in situ*. It extends back beyond the molars, and forms a segment of a larger circle than the upper incisor, which it resembles in structure.
- d.* The molars are small ; each is inserted in the jaw by several roots. The free ends of the crowns are ridged transversely, owing to plates of enamel having this direction.

#### General Dissection.

**42.** With a pair of forceps raise the skin over the sternum, nick it with scissors, and slit it from the ensiform cartilage to the symphysis of the lower jaw. Near the posterior extremity of this incision make a transverse cut parallel with the tenth ribs. Raise and reflect the flaps of skin thus formed, noting the *areolar tissue* which binds them to the subjacent structures. The *great pectoral muscles* will now be exposed, and on each, near the point of the shoulder, a soft reddish or orange mass. Similar masses are found in the axilla, and farther back on the sides of the thorax. They are parts of the "*hibernating*" or "*fat*" *gland*.

43. In front, lying on the muscles between the rami of the lower jaw, and extending to the side of the neck, are several large lymphatic glands.

44. Posterior to the lymphatics, and partly covered by them, are the highly developed **submaxillary glands**, having their inner borders in apposition, and reaching to the base of the neck. Pushing the muscles aside, trace the *submaxillary (Wharton's) ducts*, until they enter the floor of the buccal cavity.

45. On the side of the neck, posterior to the ramus of the lower jaw, is a pale buff mass of loosely aggregated glandular tissue, the **parotid gland**. The *duct of the parotid (Steno's)* is formed by the union of a number of branches, and may be traced over the surface of the masseter parallel to, and close alongside the main branch of the facial nerve, to the buccinator muscle, forming the side of the mouth, which it pierces to enter that cavity. Should the duct be difficult to detect, squeeze the gland so as to force its secretion along, and it will become distinct.

46. Anterior to the parotid is a more compact, rounded gland lying upon the posterior part of the masseter muscle : it is the extra-orbital portion of the **lachrymal gland**, and discharges its secretion upon the conjunctiva by means of a duct, which may be followed over the masseter muscle to the external canthus.

47. Separate the submaxillary glands and the muscles covering the trachea and larynx along the middle line, and the **thyroid body** will be exposed. It consists of two dark red lobes, one on either side of the trachea,

immediately posterior to the larynx, connected by a delicate bridge of the same tissue, which lies on the ventral surface of the anterior rings of the windpipe.

**48.** Remove the cervical lymphatic and submaxillary glands and the **external jugular vein** will be exposed; it may be readily dissected, and its main branches traced, owing to their distention by blood, in a recently chloroformed animal.\*

**49.** Starting from the base of the skull, which it leaves by the foramen anterior to the tympanic bulla, it runs thence to the angle of the lower jaw, where it receives branches bringing blood from the side and top of the head. It then turns backward and toward the median line, and is joined about the middle of the neck by a branch, which returns blood from the cheek, the floor of the mouth, and the glandular structures above mentioned.

**50.** The trunk thus formed, after receiving a large branch from the shoulder, passes ventral to the clavicle, and joining the **subclavian** of the same side to form the **anterior vena cava** (right or left, as the case may be), enters the thoracic cavity anterior to the first rib.

**51.** Arising from the anterior end of the sternum, and diverging to their insertion into the base of the skull behind the auditory bulla, will be seen the sterno-cleido-mastoid muscles. Raise one of these in its pos-

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\* No directions for injection are given, as if recently killed specimens are used it is quite unnecessary: in fact, rather a hindrance than a help.

terior half from the subjacent structures ; the omo-hyoid muscle will be exposed, and to its inner side the sterno-hyoid lying on the windpipe. On carefully removing the sterno-cleido-mastoid, and cutting and raising the omo-hyoid, part of the **pneumogastric nerve** will be exposed, accompanied by the **common carotid artery** and *internal jugular vein* (which is small when compared with the external), and the cervical portion of the *sympathetic nerve*. The pneumogastric is white in color, and much larger than the gray sympathetic, and may also be recognized by the fact that it crosses obliquely over the artery.

**52.** Follow the **common carotid** artery forward ; a short distance posterior to the great horn of the hyoid it divides into the *external* and *internal carotids*.

**53.** The *external carotid* is distributed to the external parts of the head, to the floor of the mouth, and to the tongue.

**54.** The *internal carotid* near the base of the skull divides into two branches, one of which enters a foramen in the tympanic bulla external to the foramen lacerum posterius, and the other the carotid canal, the opening of which is just internal to the middle of the tympanic bulla.

**55.** To open the **thoracic cavity**, clear away the pectoral muscles and cut across the chest-wall on each side between the sixth and seventh ribs ; divide the sternum, and make an antero-posterior cut on each side through the ribs, anterior to the sixth, along a line

midway between the sternum and spinal column ; the first rib, with the clavicle, should, however, be left intact, so as to avoid cutting the subclavian vessels. Turn forward the flap thus formed, clipping with scissors the delicate membrane reflected from its inner surface along the median line,\* and note :

- a. Anteriorly a collection of lymphatic glands embedded in fat, and the remains of the **thymus body**.
- b. Posterior to these, and partially concealed by the lungs, the **heart** enclosed in the **pericardium**.
- c. Prick the pericardiac sac, and inflate it with a blow-pipe,† when it will be seen to be attached to the diaphragm posteriorly, and anteriorly to be continued for a short distance along the great vessels entering and leaving the heart.
- d. On either side of the heart the pink **lungs**, which should be inflated by means of a small glass tube inserted into an opening in the trachea. Note their position in relation to the other thoracic organs and the chest-walls, also the manner in which, when they are expanded, the heart is completely enveloped by them, except a small portion of its ventral surface.
- e. Raise the lungs with forceps from the recesses in which they lie and examine them ; it will

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\* If a fresh specimen is used, which has just been killed by chloroform, and the thoracic wall immediately removed, the dissection of the heart and its vessels can be made to great advantage, provided none of the vessels are wounded.

† A convenient blow-pipe for this purpose, and the dissection of arteries, etc., can be made by inserting into one end of a piece of small rubber tubing a piece of glass tubing as a mouth-piece, and into the other end a similar bit of glass tube drawn out to a fine point.

be found that the right is composed of three main lobes, and the left of two.

- f. Each side of the chest will be seen to be lined by a smooth glistening membrane (*pleura*), which is reflected upon the lung at its root, and covers its surface.

**56.** Examine carefully the dome-shaped **diaphragm**; its mode of origin from the ribs and vertebral column; the glistening tendinous centre to which its muscular fibres converge, and which, anteriorly, is covered by a reflection of the pericardium.

**57.** Note the position of the heart, with its apex directed to the left, and its base almost in the median line. The *right auricle*, forming part of the base of the organ, may be distinguished by its dark color. A part of the *left auricle* also may be seen.

**58.** Carefully clean away the fat and glands about the base of the heart, taking care not to destroy any blood-vessels or nerves which may be embedded in them, and, on the right side, trace the **right anterior cava** from the point where it was formed by the junction of the subclavian and external jugular veins, until it enters the right auricle on its dorsal side. To complete this dissection it may be necessary to remove the clavicle and soft parts attached to it, and the first rib, in doing which care must be exercised to avoid the subclavian vessels, phrenic, pneumogastric, and sympathetic nerves.

**59.** The **left anterior cava** must be dissected with the same care; it unites with the posterior cava just before

the latter enters the right auricle. Into it enters the *azygos vein*, seen lying to the left of the bodies of the vertebræ.

**60.** **The posterior cava** (87 and 88) pierces the diaphragm a little to the right of its centre, and opens into the right auricle on its dorsal aspect.

**61.** Note, on the right side, running along the anterior cava, and following the posterior cava until it reaches the diaphragm, to which it is distributed, the right **phrenic nerve**. Follow the nerve forward as it passes dorsal to the right cava, and then along the neck, being careful to avoid the sympathetic and its ganglia, until it is found to arise from the fourth cervical nerve. On the left side the nerve follows the left anterior cava, and then passes ventral to the root of the left lung, and between its lobes, to reach the diaphragm.

**62.** Carefully clear away all remaining fat and connective tissue surrounding the heart and its vessels, taking care not to destroy the branches of the pneumogastric nerve : from the base of the left ventricle the **aorta** will be seen to arise, and to pass dorsally, and to the left to form an arch, and reach the vertebral column. From the aortic arch the following trunks are given off :

- a.* The *innominate*, dividing into the *right subclavian*, and *right carotid*.
- b.* The *left carotid*.
- c.* The *left subclavian*.

**63.** The aorta, after reaching the vertebral column, gives off the *intercostal* and other small branches, and pierces the diaphragm to enter the abdominal cavity, where it receives the name of the *abdominal aorta*, and will be traced later. That portion of the vessel beyond its arch lying within the thorax is the *thoracic aorta*.

**64.** The *subclavian artery*, leaving the thorax anterior to the first rib, runs to the fore limb, where it becomes the brachial, and may be traced as far as the elbow. The vessel then divides into the *radial* and *ulnar* arteries.

**65.** Turn now to 129, and dissect the thoracic portion of the *pneumogastric nerve*.

**66.** Roll the heart over to the right, clean away the fat which may be in the way, and find the **pulmonary artery**. It arises from the base of the right ventricle, and divides into two main trunks, one for each lung ; that to the right lung passing dorsal to the aorta : these again divide into a number of branches, which pass to the different lobes of the lungs. Should the blood have escaped from the vessels, it will be convenient to divide the aorta and superior *venæ cavæ*, and turn their stumps back upon the heart, carefully dissecting them from the adjoining structures.

**67.** Now examine the **pulmonary veins**, found dorsal to the posterior and the left anterior cava. There are several, uniting to form a single trunk on each side, and returning blood from the lungs to the left auricle.

**68.** The veins of the heart-walls may be seen coursing over its surface, and traced directly to the right auricle, which they enter.

**69.** The trachea should next be exposed throughout its entire length; passing dorsal to the heart it divides into the *right* and *left bronchi* which enter the corresponding lungs.

**70.** The *œsophagus* in the neck is dorsal to the trachea, and a little to the left of it. Passing back it enters the thorax, and lies ventral to the aorta and centra of the dorsal vertebræ, in the space between the borders of the lungs (*posterior mediastinum*); finally it pierces the diaphragm a little dorsal to its central tendon.

**71. The Heart.**—Divide the trachea and remove the heart and lungs together. Pass one blade of a pair of probe-pointed scissors \* through the pulmonary artery into the right ventricle of the heart, and open it on the ventral aspect along the right side of the ventricular septum: note—

- a. The three *semilunar valves* guarding the pulmonary opening.
- b. The pouches of the arterial walls behind the valves (*sinuses of Valsalva*).
- c. By blowing into the ventricle with a small blow-pipe the right auriculo-ventricular opening can be found to the left of the pulmonary opening, and the three flaps of the *tricuspid valve* which surround it.

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\* A very small ball of sealing-wax attached to the point of one blade of a delicate pair of eye-scissors will answer the purpose.

- d. The *chordæ tendineæ*, by which the free borders of the valves are attached to the projecting muscles (*musculi papillares*) of the ventricular wall.
- e. The projecting muscular ridges on the inner surface of the ventricle (*columnæ carneæ*).

72. Pass the scissors through the auriculo-ventricular opening into the right auricle ; lay it open and observe :

- a. The openings of the right anterior, and of the posterior cava into the auricle.
- b. Its *auricular appendix* projecting ventrally.
- c. Its smooth internal surface, except the interior of the auricular appendix, the muscles of which have a peculiar arrangement (*musculi pectinati*).

73. Separate the pulmonary artery from the aorta ; turn it forward ; pass the probe-pointed blade of the scissors through the aorta into the left ventricle, lay it open along the left side of the heart and ventricular septum, and note :

- a. The *semilunar valves*, similar to those at the pulmonary orifice, guarding the aortic opening.
- b. The *sinuses of Valsalva*, and within two of them the mouths of the coronary arteries, which supply the heart-walls. Pass bristles into these artères, and follow them along the ventricular septum, and between the auricles and ventricles.
- c. The *bicuspid valve* with its two flaps, which guard the right auriculo-ventricular opening.

- d. The structure of the *left ventricle* similar to that of the right, except that its walls are much thicker than those of the latter.

**74.** Pass the scissors through the left auriculo-ventricular opening into the left auricle, and lay it open. Observe :

- a. The openings of the two pulmonary veins.
- b. The auricular appendix with its *musculi pectinati* projecting on the dorsal side.

**75.** Divide the **trachea** near its bifurcation ; pass a probe into one of the bronchi, and lay open the tube, noting the cartilages in its wall. Then follow for some distance its ramifications, slitting up its branches (*bronchial tubes*) with probe-pointed scissors, and note that the mode of branching is dichotomous.

**76.** Open the **mouth**; divide the cheeks with scissors back to the articulation of the jaw, and note :

- a. The freely movable muscular *tongue* covered by modified mucous membrane, which, owing to its papillæ, presents a velvety appearance.
- b. The *hard palate* covered by mucous membrane thrown into transverse ridges.
- c. The *hairy pads* on the inside of the cheeks.

**77.** Disarticulate the lower jaw with a pair of strong scissors, and pull it and the tongue downward and backward ; then note :

- a. Posterior to the buccal cavity the isthmus of the fauces leading from the mouth to the pharynx.

- b. At the base of the tongue the opening of the *glottis*, guarded by the leaf-like *epiglottis*.
- c. The *soft palate* posterior to the bony palate ; it stretches horizontally between the palate bones and serves to increase greatly the depth of both nasal and buccal cavities.

**78.** Slit the soft palate along the middle line, so as to open the long passage of the naso-pharynx above it, and at its extremity note the opening of the *posterior nares*. On either side, dorsal to the posterior extremity of the internal pterygoid process, hidden by a fold of mucous membrane, the *opening of the Eustachian tube*, through which a bristle should be passed into the middle ear.

**79.** Draw the tongue out. This will raise the epiglottis ; look behind it down into the larynx, and note the *vocal cords*, and between them the *glottis*.

**80.** Open the *oesophagus* as far as the diaphragm, noting its longitudinal folds of lining membrane, and its muscular walls becoming thicker posteriorly, where it approaches the stomach.

**81.** Separate the tongue from the lower jaw, and cut away the latter ; then remove together tongue, hyoid, larynx, and the upper part of the trachea, and after noting their relations, dissect away the **larynx** and portion of trachea, and on the former note :

- a. The leaf-like *epiglottis*, a thin cartilage, which when depressed closes the opening of the larynx.

- b. Remove the mucous membrane, which closes in the larynx posteriorly, and the *vocal cords* will be more fully exposed, and will be seen to be attached ventrally to the inner surface of the thyroid cartilage, and dorsally to the arytenoid cartilages.
- c. The *arytenoid cartilages* being cleared of the soft parts covering them, are found to be V-shaped; the extremity of the posterior limb of each articulating with the cricoid cartilage, and those of the anterior limbs uniting in the median line; whilst the apices are directed ventrally and afford attachment to the vocal cords.
- d. Note that the arytenoid cartilages can be rotated outward so as to cause the vocal cords to separate.
- e. The large *thyroid cartilage*, composed of a body and a pair of wings. Projecting posteriorly from the wings is a pair of well developed cornua, which articulate by their tips with the *cricoid cartilage*.
- f. The *cricoid* is a ring of cartilage, narrow anteriorly, but expanded posteriorly to form a flat hexagonal plate, having two processes on each side: the anterior pair articulate with the arytenoid cartilages, and the posterior with the cornua of the thyroid. Anteriorly the thyroid and cricoid cartilages are united by the *crico-thyroid membrane*.

82. Slit open the trachea and larynx along the median ventral line, and observe that they are lined by a continuation of the mucous membrane of the pharynx,

and that the cartilages of the trachea are wanting on the dorsal side.

83. Divide the skin from the ensiform cartilage to the symphysis pubis, along the median line of the abdomen, cutting around and leaving intact the area on which the genito-urinary passages open. Reflect the skin on each side; make a similar cut through the remaining structures of the belly wall, also a transverse cut behind the posterior ribs, and reflect the flaps thus formed, so as to open the **abdominal cavity**, within which note the smooth glistening *peritoneum* lining its walls, and proceed to examine its contents :

- a. The posterior concave side of the diaphragm forming the anterior boundary of the abdomen.
- b. On the right side, immediately posterior to the diaphragm, and fitting into its concavity, the large *liver*, having a right and a left lobe, each of which is again subdivided.
- c. Passing forward from between the right and left lobes, and reflected from the anterior surface of the liver to be attached to the posterior surface of the diaphragm, a fold of peritoneum, forming the *coronary ligament* of the liver.
- d. Behind the liver a broad fold of peritoneum, the *great omentum*, containing fat. Turn this forward and it will be found to be attached to the posterior border of the stomach, duodenum, and transverse colon.
- e. Dorsal to the omentum the coils of *small intestine* filling the greater part of the abdominal cavity.

- f. Raise the left liver lobe, so as to expose the rest of the ventral surface of the **stomach**. Its *greater curvature* is turned toward the left side of the abdominal cavity, and its *lesser curvature* toward the right. Its left or *cardiac extremity* is greatly dilated, and toward its right or *pyloric extremity* passes into the small intestine, the line of separation being marked by a constriction (*pylorus*). The stomach presents a thinner left portion and a thicker right, and is entered at their junction by the *oesophagus*, some distance behind the diaphragm.
- g. Lying diagonally along the left side of the abdominal cavity and extending from the diaphragm backward, the dark red, elongated, and flattened **spleen**, which is closely applied to the greater curvature of the stomach.
- h. Follow the intestine. Its first portion (*duodenum*) makes a wide curve, convex toward the right, and returns to the ventral aspect of the vertebral column.
- i. From this point the gut is disposed in a number of coils, and finally opens into one side of the large intestine. The part immediately succeeding the duodenum is called *jejunum*; the part attached to the large intestine *ileum*. The latter may be said to begin where the contents of the small intestine become yellow and fecal.
- j. The *cæcum*, the first part of the **large intestine**, is a dilated portion of the gut, containing dark-colored matter; it is usually placed on the left-side of the abdominal cavity. The ileum enters it on its left side, and just beyond the

- ileum the colon is seen leaving its anterior extremity.
- k.* The *colon*, the next division of the large intestine, after passing forward on the right side behind the liver, turns back, and running along the median line, close to the lumbar muscles, enters the pelvis, and becomes—
- l.* The *rectum*, which communicates with the exterior through the anus.

**84.** Raise the intestines and note the folds of peritoneum (*mesentery, mesocolon, etc.*) by which they are slung, and in them the arches formed by branches of the *mesenteric artery*, and by the roots of the *portal vein*. The main trunk of the latter may be seen on pushing the intestine to the right, and raising the stomach and liver. It enters the liver in the notch between its right and left lobes, breaking up into a number of branches before entering the organ. With care branches from spleen, pancreas, and stomach may be traced to the *portal vein*.

**85.** The *hepatic duct* can be found in the mesentery of the duodenum. It is formed on the posterior side of the liver, near the entrance of the portal vein, by the union of a number of branches, and passes to the duodenum, which it reaches about the middle of its curve. Make a small opening in the duct and pass a bristle through it into the duodenum ; and then in the opposite direction until the liver is reached.

**86.** The *pancreas*, a scattered mass of glandular tissue, lies within the mesentery slingling the duodenum.

**87. The posterior cava.** The veins of the posterior extremities unite to form trunks, which, accompanying the arteries, enter the pelvis as the *iliac veins*.

**88.** The *iliac veins*, after receiving numerous branches returning blood from the pelvic organs and abdominal walls, unite to form the **posterior cava**, which is seen running dorsal to the aorta, where it receives large muscular branches, and also the *renal veins*. Finally the vessel passes through the liver close to its dorsal border, where it is joined by the *hepatic veins*, and issuing pierces the diaphragm. Its subsequent course has been already described (60).

**89.** Turn the intestine, stomach, spleen, and liver aside, and find the **abdominal aorta**, a continuation of the thoracic; it runs back on the dorsal side of the abdominal cavity, and is best seen by inflation through an opening in the thoracic aorta, using the flexible blow-pipe (p. 200). Its principal branches are, commencing anteriorly :

- a. The *phrenic arteries*, distributed to the diaphragm.
- b. The *celiac axis*, which splits into branches to supply the liver, stomach, spleen, and pancreas.
- c. The *superior mesenteric* supplying the intestines.
- d. Opposite the superior mesenteric the *right renal*, and a little posterior to it the *left renal artery* is given off.
- e. The *spermatic arteries*, which supply the spermatic cord and testicles in the male, and the ovaries in the female.
- f. The *inferior mesenteric*, which passes to the

colon, and finally anastomoses with the superior mesenteric. It also supplies the rectum.

**90.** The aorta finally gives off the *right* and *left common iliac arteries*, and is continued as the *middle sacral*. The iliac arteries, after giving off numerous branches to the abdominal muscles, and pelvic organs, enter the hind limbs, and become the *femoral arteries*.

**91.** The *femoral artery* runs along the inner side of the thigh, where it is subcutaneous, accompanied by the *femoral vein* and *anterior crural nerve*. Above the knee it gives off a large branch to the inner side of the leg ; the main trunk then passes dorsal to the knee-joint, and divides into the *anterior* and *posterior tibial arteries*, which supply the leg and foot. The posterior tibial artery is accompanied by the *posterior tibial nerve*.

**92.** Remove the stomach with half an inch of duodenum and œsophagus attached to it ; slit it along its greater curvature and examine the interior, noting :

- a. Lining the right half a thick, white, glandular mucous membrane thrown into folds or *rugæ*.
- b. The left half covered by thin, grayish mucous membrane, which is free from folds.
- c. The thickened ring (*pylorus*), which marks the site of the constriction seen externally between the stomach and duodenum.

**93.** Cut out the small intestine and cæcum, taking care to remove with them the pancreas : open them, observing that their thin mucous membrane is smooth,

and find the entrance of the hepatic duct into the duodenum.

94. Examine the interior of the colon and rectum ; the mucous membrane of the former is thrown into longitudinal folds ; near the cæcum they have an oblique arrangement.

95. The length of the intestine is about ten times that of the body cavity (thorax and abdomen).

96. The kidneys will now be exposed on each side, ventral to the lumbar muscles, the right being situated anterior to the left.

97. Clear away the fat and peritoneum, and note the renal vein and artery passing in and out of the organ.

98. Posterior to these is seen the *ureter* leaving the kidney ; at first dilated to form the *pelvis* of the kidney, it soon becomes narrowed to a fine tube, which passing backward and toward the middle line between the peritoneum and lumbar muscles enters the pelvis, and passes dorsal to the *vas deferens* (103, d) to enter the bladder.

99. Anterior to each kidney is a pyramidal pink body, the **supra-renal capsule** or *adrenal body*.

100. Remove one of the **kidneys** and note :

- a. Its bean shape, and the notch (*hilus*) in its inner border.
- b. Its smooth external surface, and the fibrous

capsule investing it, which may be readily removed.

- c. The artery, vein, and ureter occupying the hilus.

**101.** Split the organ longitudinally from its external to its inner border, and on the cut surface exposed observe :

- a. An external (*cortical*) portion and an internal paler colored (*medullary*) portion.
- b. The radial appearance of the medullary part, which is composed principally of tubes converging toward the pelvis, where they meet in a large papilla which projects into the ureter.

**102. The Genito-urinary Organs.**—If the specimen is a male, note :

- a. The *prepuce* (2, f) in the middle line of the abdominal wall posteriorly ; by retracting it, and slitting it along its median ventral and dorsal lines, the *penis* will be exposed, presenting a somewhat enlarged extremity, the *glans penis*.
- b. That the penis is curved backward, and attached to the abdominal wall by fibrous tissue.
- c. Closely attached by dense areolar tissue to the side of the penis, are a pair of flask-shaped glands (*preputial glands*), opening by ducts within the fold of the prepuce ; their thick white secretion may be forced out by pressure.
- d. Dorsal to the symphysis pubis within the pelvic cavity is the *bladder*, placed in the median line and having thick muscular walls.
- e. Divide the skin from the root of the penis

back to the margin of the anus : on reflecting it the *cremasteric pouches* on either side will be exposed, extending posteriorly as far as the anus. Covering their external surface is seen a layer of muscle continued upon them from the external oblique muscles of the abdomen.

- f. Through the walls of the *cremasteric pouches* may usually be seen the testicles, which may be pushed through the inguinal canal into the abdominal cavity.

103. Slit open one of the *cremasteric pouches* and the *inguinal canal*, and note :

- a. Lining them the *tunica vaginalis*, a delicate membrane, which is a continuation of the peritoneum. Leaving the walls of the pouch it is reflected upon the testicle and its appendages ; after leaving the latter its layers form a fold filled with fat and extending into the abdominal cavity.
- b. The testicle is an ovoid organ, having large tortuous vessels on its ventral surface. Remove the fat from its anterior portion, and the *globus major* of the *epididymis* will be seen fitting on the anterior end of the testicle ; it is made up of numerous convolutions of a duct which may be traced to its commencement at the dorsal border of the testicle near its anterior end.
- c. Trace the *epididymis* along the dorsal surface of the testicle, where it becomes constricted to form the *body*. Posteriorly will be seen another enlargement, the *globus minor*.

- d. Arising from the *globus minor* and running forward dorsal to the testicle is a thick cord, the **vas deferens**, which turns mesially to enter the urethra near the *verumontanum* (105), as may be seen later by passing on into the urethra a bristle through an opening made in its walls.
- e. Surrounding the termination of the *vas deferens* and *vesicula seminalis* a granular gland.
- f. The **vesiculae seminales** are two crescentic masses, having a cockscomb-like form, placed anterior to the bladder. The duct of one of them should be traced by carefully cleaning away the surrounding glandular tissue (103, e) and passing a bristle through it, when it will be found to open into the urethra with the *vas deferens*.
- g. Lying along the outer border of each *vesicula seminalis* is a bladder-like organ, attached to it by connective tissue and terminating in a long neck, which passing dorsal to the *vas deferens* opens into the neck of the bladder, near the common opening of the *vesicula seminalis* and *vas deferens*.

**104.** Remove the bones and muscles on the ventral side of the pelvis, and expose the whole **penis**. Note :

- a. That on its ventral side, *when it is extended posteriorly*, it is composed of two *corpora cavernosa* terminating at the *glans penis* and attached, posteriorly, to the rami of the ischia.
- b. That the *corpus spongiosum*, dorsal to the *corpora cavernosa*, and continuous with the *glans penis*

posteriorly, is traversed by the *urethra*, whilst anteriorly it reaches to near the base of the bladder. Pass a bristle from the urethral orifice along the canal until it enters the bladder.

- c. Divide on one side and turn forward the muscle (erector penis) which passes from the root of the penis to the ischium ; there will be then exposed a flask-shaped gland (*Cowper's gland*), emptying by an elongated duct into the urethra near the median dorsal line, just posterior to the arch of the pubis. Open its duct and pass a bristle through it into the urethra.
- d. The *pudic nerves* (140), terminating as the dorsal nerves of the penis in the corpora cavernosa.
- e. Dorsal to the neck of the bladder and commencement of the urethra is a bilobed mass attached to the former, the **prostate gland**.

**105.** Open the urethra along the ventral side of the penis between the corpora cavernosa with a pair of small probe-pointed scissors, following as a guide the bristle previously passed along it. Remove the plug of secretion found in it and find the openings of the vasa deferentia and vesiculæ seminales on each side of a long, whitish elevation, the *verumontanum*, on its upper side.

**106.** If the rat has been recently killed slit open one of its *testicles* and remove some of the whitish fluid which it contains ; examine a little of it with a microscope (300 diameters), and note the great length of the *spermatozoa* which it contains, having heads shaped like a bent pruning-knife, and carrying a long filiform tail.

107. Dissect out the cartilage which may be felt in the glans penis.

108. If the animal be a female, turn the intestines out of the way, and note :

- a. Immediately behind the kidneys the **ovaries**, red, granular masses, one on each side, suspended by a fold of peritoneum (*mesovarium*) containing much fat.
- b. Behind the ovaries, the short *Fallopian tubes*, having their anterior fimbriated extremities attached to the ovary, and terminating posteriorly in the horns of the **uterus**. If the animal be pregnant, the latter will contain a number of embryos.
- c. The uterine horns posteriorly becoming continuous with the anterior end of the **vagina**.
- d. Cut away with stout scissors the ventral wall of the pelvis and the **vagina** will be exposed, having on its ventral side a pair of slightly developed *corpora cavernosa*, terminating in the **clitoris**.
- e. Ventral to the uterus and anterior to the symphysis pubis is the **bladder**, which should be opened, and a bristle passed through it into the long urethra, which will be found to open at the base of the clitoris. Slit open the urethra with a pair of probe-pointed scissors and examine its interior.
- f. The termination of the *pudic nerves*, which may be traced from the clitoris into the pelvis by chipping away the bone and removing the pelvic muscles.

- g. Just beneath the skin, near the corpora cavernosa, are found two glands similar to the preputial glands of the male.
- h. Slit open the vagina along its ventral aspect up to its junction with the uterus ; observe its muscular walls and its mucous membrane thrown into longitudinal folds.
- i. The *os uteri* is now exposed, and is found to be double. Surrounding it, beneath the mucous membrane, are four cartilages, one dorsal, one ventral, and two lateral. A fifth cartilage is found in the vertical partition between its openings. Pass probes through each opening into the corresponding horn of the uterus.

**109.** Obtain a female well advanced in pregnancy. Dissect away the skin of the belly and thorax, and note the **mammary glands** (larger than those of a non-gravid female) adherent to its deeper side.

**110.** Open the abdomen carefully. On each side of it will be found the immensely enlarged uterine horns ; spread them out, and note :

- a. The folds of peritoneum slinging them, and the large blood-vessels in them ; trace the main vein from each until it opens into the inferior cava close behind the renal vein.
- b. The constrictions which separate each horn into a number of uterine chambers, each containing a foetus. Through the thin transparent uterine wall the embryos may often be seen moving, if the mother was recently killed.
- c. On that side of each uterine chamber which is

attached to the peritoneum there will be seen a darkened circular patch, with large blood-vessels running to and from it in the peritoneum. This is the *placenta* seen through the uterine wall.

**111.** Remove one horn of the uterus, and very carefully divide its thin wall along the border opposite the placenta, so as to expose its contents.

- a. Lying close against the inner surface of the uterus is a very thin, transparent membrane, the *amnion*. At certain stages of pregnancy a considerable amount of transparent, colorless amniotic fluid will be found under it, while at other times it lies close against the foetus, and is hard to see.
- b. Divide the amnion along the middle dorsal line of the embryo, and turn it back until it is found to be attached to the belly of the foetus.
- c. At the point where the amnion joins the embryo arises the *umbilical cord*. Evert the uterus and amnion so as to turn the embryo out of them. The umbilical cord will be found to proceed to the placenta, which is soft, very vascular, *discoidal*, and adheres pretty firmly to the interior of the uterus.

**112. The Brain and Spinal Cord.**—Chip away the cranial vault with a scalpel or stout scissors, noting the *dura mater* which lines it, and with scissors cut away the neural arches of the anterior cervical vertebræ, so as to expose the brain and anterior end of the spinal column. The brain fills the cavity of the skull almost

completely. Covering it is the glistening *arachnoid*, and beneath this the *pia mater* containing blood-vessels. Remove its membranes from before backward, and note on its dorsal aspect :

- a. The *olfactory lobes* (*rhinencephalon*), which are large, elongated, and grayish.
- b. The *cerebral hemispheres* (*prosencephalon*), which are smooth and separated by a deep median fissure.
- c. Push apart the hemispheres, and the *corpus callosum*, the great commissure uniting them, will be displayed ; it is white when compared with the neighboring brain substance.
- d. The *cerebellum*, with large *right* and *left lateral lobes*, greatly convoluted, the convolutions having a general transverse and parallel arrangement. Along the median line an elevation presents itself, the *vermiform process*. Arising from the outer side of each lateral lobe is the *flocculus*, lodged in a cavity of the skull.
- e. At the point of meeting of the cerebral hemispheres and cerebellum is the small *pineal gland* (*epiphysis cerebri*), which may possibly have been torn away in removing the pia mater.
- f. Raise the posterior border of the cerebrum and the front border of the cerebellum, and two pairs of white masses, the anterior being the larger, will be exposed ; they are the *corpora quadrigemina*.
- g. Posterior to these is a delicate sheet of nerve matter (*valve of Vieussens*) roofing over the anterior portion of the fourth ventricle (112, h).

- h.* Raise the posterior border of the cerebellum so as to expose the anterior portion of the *medulla oblongata*; on it will be seen a chamber, the *fourth ventricle*, roofed in dorsally by a thin, grayish-red layer. Tear this layer carefully away and open the ventricle; it is bounded laterally by diverging columns continued from the spinal cord, which pass into the cerebellum and form its *posterior peduncles*.
- i.* Note that the fourth ventricle at its posterior part (*calamus scriptorius*) communicates with the central canal (122) of the spinal cord.
- j.* That the brain and spinal cord at their point of junction form an angle.

**113.** Raise the brain from the base of the skull and the dura mater, and note on its ventral surface successively:

- a.* The *olfactory lobes*, giving origin to the olfactory nerves, which pierce the cribriform plate of the ethmoid bone.
- b.* The *optic nerves*, passing forward from the *optic commissure*, and each entering an orbit.
- c.* Cut the optic nerves, and turning the brain farther back, the *infundibulum*, a downward prolongation of the third ventricle (119, *b*), will be seen behind the optic commissure.
- d.* The *pituitary body*, a pink mass, attached to the infundibulum. It is covered by a fold of dura mater.
- e.* External to the posterior part of the infundibulum the *crura cerebri* uniting the hemispheres to the hinder part of the brain.

- f. The *third pair of nerves*, arising from the ventral and inner aspect of the crura, and running forward along the cranial floor, beneath the dura mater, external to the optic nerves.
- g. Posterior to the infundibulum the *pons varolii*, passing across from one cerebellar lobe to the other.
- h. Internal to the third nerves the *sixth* may be exposed by removing the dura mater with care ; being traced back they are found to arise from the anterior portion of the medulla oblongata.
- i. External to the third the *fourth* nerves are seen ; after leaving the valve of Vieuussens they reach the margins of the bony ridges which extend inward between the cerebrum and cerebellum, and from thence they may be traced to the anterior lacerated foramina, through which they pass into the orbit, accompanied by the third and sixth pairs.
- j. Posterior to the pons varolii the ventral surface of the medulla oblongata will be seen : do not raise it far from the base of the skull until after the dissection described in 114.

**114.** Replace the brain and push it gently to one side, when the following may be examined :

- a. The great trunk of the *fifth nerve*, arising from the side of the pons varolii.
- b. Posterior to the fifth the *seventh and eighth nerves* arise from the side of the medulla oblongata and enter the auditory capsule separately ; the former being anterior to the latter.
- c. Posterior to these the *ninth and tenth nerves*,

given off close together from the side of the medulla.

- d. The *eleventh nerve* runs forward on the side of the medulla, and then turns out alongside the tenth, and accompanied by it, and the ninth, issues from the skull by the posterior lacerated foramen (Fig. 2, 22).
- e. Succeeding these the *twelfth nerve*, arising from the ventral aspect of the medulla by a number of filaments, and escaping from the skull cavity by the condyloid foramen (Fig. 2, 23).

**115.** Expose the remainder of the *spinal cord* by cutting away with scissors the neural arches of the vertebræ. Note :

- a. That the *dura mater* of the cord is not adherent to the bones.
- b. The *cervical* and *lumbar enlargements*, from which arise the nerves forming the *brachial* and *sciatic plexuses* respectively.
- c. In the posterior lumbar region the cord rapidly decreases in size, and finally terminates in a slender thread (*filum terminale*) which lies between a number of long nerve-roots which form the *cauda equina*.

**116.** Examine the origin of one of the *cervical spinal nerves*, and note that it arises by two roots, a ventral and dorsal. Each root is formed by the union of a number of filaments springing from the cord. The roots then unite to form a single trunk, which passes out of the spinal canal by an intervertebral foramen. Just where the roots unite the dorsal root presents a *ganglion*.

117. Remove the spinal cord and brain from the same, or a fresh specimen, and place them in a 75 per cent. solution of alcohol to harden.

118. Make a longitudinal median dorso-ventral section of the brain, when it becomes moderately hardened, and note :

- a. The *corpus callosum*, or great transverse commissure of the cerebral hemispheres, the divided surface of which may be distinguished by its denser structure and somewhat glistening appearance.
- b. Ventral to the corpus callosum, and attached to it posteriorly, the *fornix*, of similar structure, which forms the roof of the *third ventricle*, and is continued downward anteriorly into the base of the brain.
- c. Gently scrape away the substance of the hemisphere of one side, until the *corpus callosum* is reached, and its fibres traced into the hemisphere.
- d. Raise the corpus callosum and depress the fornix, when the *lateral ventricle* (which is normally separated from that of the opposite side by the *septum lucidum*, a delicate sheet of brain-matter connected with the corpus callosum above and fornix below) will be opened, and a rounded mass (*corpus striatum*) exposed projecting upon its floor.
- e. The *anterior horn* of the lateral ventricle, turning downward anterior and internal to the corpus striatum.
- f. The *middle horn*, passing outward and then ven-

trally, may be examined by tearing through the roof and outer wall of the hemisphere. The inner wall of the middle horn presents a rounded and curved eminence, reaching to its ventral extremity (*hippocampus major*).

- g. Situated in the depression between the corpus striatum and optic thalamus (119, c), a narrow white band which extends into the middle horn of the ventricle (*tænia semicircularis*).
- h. Along the concave border of the hippocampus major, a small ridge of white matter (*tænia hippocampi*), which may be followed until it is lost in the fornix, of which it constitutes one of the *posterior pillars*.
- i. Posterior to the hemisphere, and completely hidden by it when viewed from above, the *corpora quadrigemina* of one side.
- j. Ventral to the corpora quadrigemina one of the *crura* of the brain, which may be followed forward until it enters the substance of the hemisphere.
- k. Posterior to the corpora quadrigemina is half the *cerebellum*, showing numerous deep convolutions upon its cut surface.
- l. Ventral to the cerebellum, the *medulla oblongata* and *pons varolii*, the latter a transverse commissure uniting the opposite sides of the cerebellum, and also containing fibres of the cord on their way to the hemispheres.

**119.** A second brain should now be dissected from above by removing the upper portion of the hemispheres and the corpus callosum and exposing the

fornix, when the following additional points may be noted :

- a. That the *fornix*, which forms the roof of the third ventricle, extends forward and ventrally, terminating in two bands of white matter, the *anterior pillars of the fornix*, which principally form the anterior boundary of the third ventricle, or *lamina terminalis*.
- b. Tear through the fornix behind, raise and turn it forward, and the *third ventricle* will be opened.
- c. Forming the lateral boundaries of the third ventricle the *optic thalami*.
- d. Passing from one optic thalamus to the other (if not destroyed by rough handling), the *middle commissure* of the third ventricle, composed of gray matter.
- e. The *foramen of Monro*, by which the lateral and third ventricles communicate, found close to the point of meeting of the *tæniæ semicirculares* and anterior pillars of the fornix.
- f. The *iter a tertio ad quartum ventriculum* (*aque-duct of Sylvius*), and the *posterior commissure* of the third ventricle passing over its anterior extremity, can be exposed by carefully removing the *corpora quadrigemina* and other brain substance forming its roof.
- g. The continuation of the ventricle downward to form the *infundibulum* (113, c).
- h. By scraping away the brain near the inferior extremity of the fornix the *anterior commissure* of the third ventricle will be exposed.

**120.** Open carefully from above the lateral ventri-

cles, and if the brain has not been too much hardened, or, better still, if a fresh one be used, a delicate vascular membrane (*velum interpositum*) will be seen projecting into each ; it is an extension of the pia mater through the *transverse fissure of the brain*, found by raising posteriorly the fornix and cerebral lobes, beneath which it enters the third and lateral ventricles. Anterior to the *tæniae hippocampi*, where its vessels are more conspicuous, it forms the *choroid plexuses*, which communicate through the foramen of Monro. In the third ventricle it is difficult to find, being removed with the fornix, to the ventral surface of which it is attached.

**121.** Raise the cerebellum and observe that it is connected with the medulla oblongata and cerebrum by its *posterior* and *anterior peduncles*, and laterally is continuous with the pons varolii by its *middle peduncles*.

**122.** Transverse sections should now be made of the spinal cord at different points, and its minute *central canal* and varying proportions of gray and white matter noted with a hand lens : the gray matter presents only rudimentary *anterior* and *posterior horns*.

**123. Distribution of the Cranial Nerves.**—Take a perfectly fresh rat's head. Open the skull (112) and very carefully remove the brain, dividing the nerves which arise from it with sharp scissors close to their origin.

**124. The olfactory nerves** are a number of filaments arising from the anterior ends of the olfactory lobes of the brain, and passing through the openings in the cribriform plate of the ethmoid bone to enter the nasal

cavity, to the mucous membrane of which they are distributed.

**125.** The optic tracts, after meeting to form the optic chiasma (113, *b*) on the base of the brain, continue in front of it as the **optic nerves** which pass out of the skull by the optic foramina and enter the eyeballs.

**126.** The distribution of the **third, fourth, and sixth** nerves is best studied with the dissection of the orbit (143).

**127.** The **fifth nerve** arises from the pons varolii by two roots which lie close together ; the larger of the two enters an enlargement, the *Gasserian ganglion*, lodged in a depression of the floor of the skull. Beyond the ganglion the fifth nerve divides into :

- a.* The *ophthalmic nerve*, which enters the orbito-temporal fossa by the foramen lacerum anterius, and is best dissected with the contents of the orbit (143, *j*).
- b.* The *superior maxillary*, a large branch, also enters the orbito-temporal fossa by the foramen lacerum anterius, lying in it dorsal to the alveolar portion of the superior maxilla, and sending branches through the bone to the upper molars : it issues through the infra-orbital fissure to be distributed to the skin of the face and roots of the vibrissæ.
- c.* The *inferior maxillary* leaves the cranial cavity by the foramen ovale (Fig. 2, 20). Chip away the bone, so as to follow the nerve to the outside of the skull, where it immediately gives off several branches to the muscles of mastication,

and also the *lingual* nerve. Disarticulate the lower jaw and divide the skin of the cheek so as to lay the mouth well open ; then follow the lingual nerve under the mucous membrane of the mouth beneath the tongue, until it turns up to enter that organ. The main trunk of the inferior maxillary nerve may be traced between the muscles of mastication until it enters the *dental foramen* (10, f) of the inferior maxilla ; passing through the *dental canal*, where it gives branches to the inferior molars, it escapes by the *mental foramen* to be distributed to the integument of the chin and lower jaw.

**128.** Remove the skin from the side of the face and neck and the branches of the **seventh nerve** will be seen lying on the muscles of mastication. Trace these up until they are found to issue as a common trunk from a foramen external to the bulla of the tympanic bone. Chip away the bone from above and follow the nerve through the auditory capsule to the cranial cavity.

**129.** Find the **tenth nerve** (*pneumogastric*) on the side of the neck, where it lies ventral to the carotid artery, and trace it up to the base of the skull, taking care not to cut the other cranial nerves which cross it. The tenth nerve, arising from the side of the medulla oblongata, leaves the skull by the posterior lacerated foramen and runs posteriorly along the ventral aspect of the neck to enter the thoracic cavity, accompanied by the jugular vein, carotid artery, and sympathetic nerve. Soon after leaving the skull it is marked by a ganglionic enlargement, posterior to which it gives

off the *superior laryngeal nerve*, which is distributed to the larynx. The nerve on the left side, after entering the thorax, passes ventral to the arch of the aorta, and on the right side ventral to the innominate artery, giving off the *recurrent laryngeals*, which turn around those vessels and run forward to the neck, where they can be followed along the outer side of the trachea to the larynx. The main trunks then give branches to the lungs and heart, and passing alongside the œsophagus pierce the diaphragm along with it, and are distributed, the left to the ventral and the right to the dorsal surface of the stomach.

**130. The twelfth nerve (*hypoglossal*)**, leaving the side of the medulla oblongata, passes through the condyloid foramen, and will be easily found where it crosses ventral to the pneumogastric close to the tympanic bulla. It runs anteriorly between the hyoid bone and angle of the lower jaw to the tongue, which it enters on its ventral surface, as may be seen by parting the muscles.

**131. The ninth nerve (*glosso-pharyngeal*)**, arising from the medulla oblongata close to the tenth nerve, leaves the skull by the foramen lacerum posterius and will be found lying anterior to the twelfth nerve, close to the skull, and having a deeper course than the latter. It runs forward dorsal to the hyoid bone, to be distributed to the pharynx and tongue.

**132. The eleventh nerve (*spinal accessory*)**, arising by a number of filaments from the anterior portion of the spinal cord between the anterior and posterior roots of the spinal nerves, enters the skull by the foramen magnum, and uniting with the ninth and tenth nerves,

leaves it again by the foramen lacerum posterius, and crossing the hypoglossal ventrally supplies several muscles of the neck.

**133.** The spinal nerves may be described as *cervical*, *dorsal*, *lumbar*, *sacral*, and *coccygeal*.

**134.** There are eight pairs of *cervical spinal nerves*, the first escaping from the spinal canal by the foramen in the neural arch of the atlas (13, a), and the remaining seven pairs passing out by the intervertebral foramina. The first, second, third, and part of the fourth nerves are distributed to the neck muscles. From the fourth is given off the *phrenic nerve* (61).

**135.** The fifth, sixth, seventh, and eighth cervical nerves, larger than the preceding, together with the first dorsal, enter the **brachial plexus**, from which is given off :

- a. The *ulnar nerve*, which, passing posterior to the inner condyle of the humerus, supplies the muscles of the posterior (ulnar) aspect of the forearm.
- b. The *median nerve*, which, being followed over the anterior surface of the elbow-joint, is found to supply the muscles of the inner side of the arm.
- c. The *circumflex nerve*, which, curling around the posterior aspect of the humerus, passes over the elbow-joint and goes to the outer side of the arm as the *radial*.
- d. Numerous branches to the thorax.

**136.** There are thirteen pairs of *dorsal spinal nerves*.

which pass out from the spinal canal by the intervertebral foramina, and, with the exception of the first, supply the walls of the thorax and of the anterior part of the abdomen.

**137.** There are six pairs of *lumbar nerves*. The first, second, and third pairs supply the abdominal walls. From the third lumbar nerve on either side is given off the *genital nerve*, which goes to the cord and testicle in the male.

#### The Lumbar Plexus.

**138.** Part of the third, the fourth, and part of the fifth lumbar nerves on either side unite, and from them are derived :

- a. The *anterior crural nerve*, distributed to the inner aspect of the hind limb.
- b. The *obturator nerve*, which may be traced to the obturator foramen (31), through which it passes to be distributed to muscles in its neighborhood.

#### The Sacral Plexus.

**139.** The remainder of the fifth lumbar nerve, the sixth, and part of the first sacral on either side unite to form the *sciatic nerve*, which, issuing from the pelvis by the sacro-sciatic foramen, may be traced by parting the posterior muscles of the thigh, in the lower part of which it divides into the *anterior* and *posterior tibial nerves*.

**140.** There are three pairs of *sacral nerves*; part of the first and second uniting form a trunk which sup-

plies the pelvic structures and gluteal region, and gives off the *pudic nerve* to the penis in the male and clitoris in the female.

**141.** The remainder of the second sacral nerve with the third and fourth coccygeal nerves on either side uniting form the *caudal nerve*, which runs along the tail dorsal to the transverse processes of the caudal vertebræ.

**142.** Find the **sympathetic nerve** in the neck, where it lies dorsal to the pneumogastric nerve, and follow it to its commencement at the posterior lacerated foramen in the base of the skull. From this point it runs posteriorly along the sides of the neck on the muscles covering the vertebræ, and presents a large spindle-shaped ganglion (*superior cervical*) close to the bifurcation of the common carotid artery. At the base of the neck it is marked by a second ganglion (*inferior cervical*), followed in the thorax by a chain of ganglia, one on the head of each rib. Posterior to the diaphragm it may be traced on separating the lumbar muscles from the spinal column. In the thorax, from the ganglia in the neighborhood of the eleventh and twelfth ribs, are given off large branches (*splanchnic nerves*), which enter the abdomen and communicate with an aggregation of ganglia constituting the *solar plexus*. The lumbar ganglia also give off branches to form plexuses containing numerous ganglia, from which branches pass to the viscera.

**143.** To dissect the contents of the orbit open the cranial cavity from above and carefully remove the

brain ; then cut through the skin about a fourth of an inch from the eye and remove it. Carefully separate the eyeball from the bony wall of the orbit above, keeping close to the bone so as to avoid injuring either its muscles or nerves, and leaving the attachment of the oblique muscles to the internal angle of the orbit. Cut through the fascia covering the zygomatic arch and separate the eyeball from the muscles bounding its socket, ventrally and posteriorly, and note :

- a. The *intra-orbital portion of the lachrymal gland*, placed near the external canthus of the eyelids ; it so closely resembles the neighboring muscles that it is easily overlooked.
- b. With a pair of sharp-pointed scissors, and keeping away from the nasal branch of the ophthalmic, which pierces the bone near the optic foramen, cut out a wedge-shaped piece of the inner wall of the orbit, having its apex at the optic foramen, and examine the *optic nerve*.
- c. Arising from the bone near the optic foramen, the *superior oblique muscle* directed outward to a fibro-cartilaginous ring at the anterior angle of the orbit, through which it passes, and then turns posteriorly to be attached to the superior surface of the eyeball.
- d. The *fourth nerve (pathetic)*, passing from the skull cavity (where it lies beneath the dura mater external to the ophthalmic division of the fifth nerve) by the foramen lacerum anterius ( $7, d$ ) dorsal to the optic nerve, may be followed to the superior oblique muscle.
- e. The large yellow *Harderian gland*, almost enveloping the eyeball.

- f. Arising from the anterior angle of the orbit the *inferior oblique muscle*, passing backward over the Harderian gland to be attached to the eyeball.
- g. Remove the Harderian gland by first loosening the attachment of its border to the eyeball and then seizing it with a pair of large forceps and drawing it away from the orbit, when its remaining attachments will be found to yield easily and the muscles and nerves of the eye be more fully exposed.
- h. **The third nerve (oculo-motor)**, entering the orbit by the anterior lacerated foramen, gives off branches to the *superior rectus muscle* and to the *levator palpebrae*, and passing ventral to the optic nerve breaks up into branches for the *inferior rectus*, *inferior oblique*, and *internal rectus muscles*.
- i. **The sixth nerve (abducens)**, which lies beneath the dura mater, ventral to the third nerve, passes through the foramen lacerum anterius, and may be traced beneath the nasal branch of the ophthalmic to the *external rectus muscle*, which arising from the internal orbital wall is attached to the posterior aspect of the eyeball.
- j. The *ophthalmic division of the fifth*, a large trunk seen beneath the dura mater between the third and fourth nerves, divides into two portions, and passes through the foramen lacerum anterius into the orbit. One portion passes to the posterior angle of the orbit, and is distributed to the integument in that region ; the other,

passing over the optic nerve, divides into the supraorbital and nasal nerves.

- k.* The *supraorbital* runs dorsal to the Harderian gland, and is distributed to the integument of the upper lid and forehead.
- l.* The *nasal* passes through a foramen in the orbital wall near the optic foramen, enters again the cranial cavity, and passing along the external margin of the cribriform plate of the ethmoid bone pierces it to reach the nasal cavity.
- m.* Separate the four *recti muscles* from the eyeball, and examine their origin at the back of the orbit, and their attachments to the sclerotic dorsally, ventrally, externally, and internally.
- n.* Remove the recti muscles and a muscle will be seen surrounding the optic nerve and enveloping the posterior part of the eyeball ; this is the *choanoid muscle*.

**144. The Eye.**—Clean the eyeball and note :

- a.* The large convex *cornea*.
- b.* The *iris*, with its pupillary opening, often so contracted as to be almost invisible.
- c.* The pearly *sclerotic* forming the back of the eyeball, and the black *choroid* coat showing through it.
- d.* The *optic nerve* entering the globe.

**145.** Divide the coats of the eyeball along the equatorial zone. On the posterior half note :

- a.* The transparent *vitreous* humor filling its cavity.

- b. The *retina*, a delicate film.
- c. Outside the retina the *choroid*, filled with black pigment.
- d. The *optic nerve entrance*.

On the anterior half note :

- a. The highly convex *lens*, held in position by the *suspensory ligament* and separating the anterior chamber of the eye, containing the *aqueous humor* from the posterior chamber filled by the *vitreous*.
- b. The *iris*, external to the lens, with its pupillary opening and its attachment along the line of meeting of cornea and sclerotic.

**146. The Ear.**—From a macerated skull chip away with a scalpel a small portion of the ventral and median wall of the tympanic bulla, and expose the cavity of the middle ear. Note :

- a. At the inner and anterior extremity of the auditory capsule, where it abuts against the basi-sphenoid, the opening of the bony *Eustachian canal*, through which a bristle should be passed into the middle ear.
- b. The *tympanic membrane* stretched upon a ring of bone.
- c. Attached to the tympanic membrane, the handle of the *malleus*, the first of the chain of ossicles connecting the drum membrane with the internal ear.
- d. If necessary, slightly enlarge the opening of the external auditory meatus, and within its upper margin will be seen the articulation of

the *incus*, the second bone of the chain, malleus. The incus has a downward ing process which articulates with of the stapes.

- e. Through the opening in the ventricle the bulla, with a hand lens (if the membrane of the middle ear has been removed) may be seen the *stapes*, placed at right angles to the extremity of the incus, with its head inserted into the *fenestra ovalis*, which is directly above the centre of a small elevation on the inner wall of the middle ear cavity, the position of the *cochlea*.
- f. Posterior to the elevation caused by the bulla is the *fenestra rotunda*, or *scala tympani*.
- g. Shave away the wall of the middle ear cavity, so that it can be seen on the inner side of the *vestibule* and the spiral canal, which will be exposed. Within the cavity of the vestibule will be distinguished several of the *circular canals*.
- h. From the interior of the middle ear cavity, seen on the inner wall, will be visible two small elevations due to the

130

s, brachial, 225, 233; choroid,  
 ; sciatic, 225; solar, 235  
 x, 192  
 Varolii, 224, 227  
 al vein, 211  
 erior lacerated foramen, 177;  
 eidiastinum, 204; nares, 176, 207;  
 latine foramina, 176; peduncles  
 of the cerebellum, 223, 229; tibial  
 artery, 213; tibial nerve, 213, 234;  
 vena cava, 202, 212  
     tzygapophyses, 186, 188  
     frontals, 181  
     maxillæ, 178  
     epalatine foramina, 176  
     eparation of skeleton, 175  
     repuce, 175, 215  
     reputal glands, 215  
     resphenoid, 182  
 Probe-pointed scissors, 204  
 Process, acromion, 190; odontoid  
     of axis, 187; olecranon, 191; spinous  
     of vertebræ, 185, 187, 189;  
     vermiform of cerebellum, 222  
 Processes, condyloid of lower jaw,  
     184; coronoid, 184; paroccipital,  
     183; pterygoid, 182; transverse  
     of vertebræ, 185, 186, 187, 188, 189  
 Prostate gland, 218  
 Pterygoid processes, 182  
 Pubis, 193  
 Pudic nerve, 218, 219  
 Pulmonary artery, 203; veins, 203  
 Pylorus, 213

**R**ADIALE of carpus, 191

Radial artery, 203; nerve, 233  
 Radius, 191  
 Rectum, 211  
 Recurrent laryngeal nerves, 232  
 Renal artery, 212, 214; veins, 212,  
     214  
 Retina, 239  
 Ribs, 189  
 Right anterior vena cava, 198, 201;  
     common iliac artery, 213; renal  
     artery, 212; subclavian artery,  
     202, 203  
 Root of spinal nerves, 225

**S**ACRAL nerves, 233, 234; ver-  
     tebræ, 188  
 Sagittal suture, 182

**CÆCUM**, 210

Calamus scriptorius, 223

Calcaneum, 194

Canal, carotid, 177; Eustachian, 177, 239; dental, 185, 231; inguinal, 216; lachrymal, 174

Canthi of eyelids, 174

Capitulum of rib, 189

Carotid arteries, 199

Carpalia, 192

Carpus, 191

Cartilage, cricoid, 208; of penis, 219; thyroid, 208

Cartilages, arytenoid, 208; costal, 189; of the os uteri, 220; of the trachea, 208

Carunculus, 174

Cauda equina, 225

Caudal nerves, 235; vertebræ, 188

Central canal of spinal cord, 229

Centrale, of carpus, 192; of tarsus, 195

Centrum of vertebra, 185, 188

Cerebellum, 222, 227; peduncles of, 229

Cerebral hemispheres (prosencephalon), 222

Cervical, enlargement of spinal cord, 225; ganglion of sympathetic, 235; nerves, 233; rib, 185

Characters, general external, 173; of sub-class Monodelphia, 170; of the Rodentia, 171; zoological of Mammalia, 169

Choanoid muscle, 238

Chordæ tendineæ, 205

Choroid, 238, 239; plexuses, 229

Cilia, 174

Circumflex nerve, 233

Clavicle, 190

Clitoris, 175, 219

Coccygeal nerves, 235

Cochlea, 240

Colon, 211

Columnæ carneæ, 205

Commissures of the third ventricle, 228

Condyles, occipital, 177, 183; of femur, 193; of humerus, 191

Condyloid foramen, 177, 183; processes of the lower jaw, 184

Cornea, 238

Coronal suture, 182

Coronary ligament of the liver, 209

Corpora cavernosa, 217, 219; quadrigemina, 222

Corpus callosum, 222, 226; spongiosum, 217; striatum, 226

Costal cartilages, 189

Cowper's gland, 218

Cremasteric pouches, 216

Cricoid cartilage, 208

Crico-thyroid membrane, 208

Crista galli, 181

Crura cerebri, 223, 227

Cuboid bone, 195

Cuneiform bones, 195

**DENTAL** canal, 185, 231; foramen, 185, 231; formula, 195

Diaphragm, 201, 209

Diastema, 184

Digits of manus, 175, 192; of pes, 195

Dissection of the abdominal cavity, 209; of the arteries, 199, 202, 203, 212; of the brain and spinal cord, 221; of the cranial nerves, 229; of the genito-urinary organs, 215; of the gravid uterus, 220; of the neck, 196; of the spinal nerves, 233; of the orbit, 235; of the veins, 198, 199, 201, 202, 203, 211, 212

Dorsal spinal nerves, 233; vertebræ, 187

Duct, hepatic, 211, 214; of lachrymal, gland, 197; of parotid gland (Steno's), 197; of submaxillary gland (Wharton's), 197

Duodenum, 210

Dura mater of brain, 221; of cord, 225

**EAR**, 239

Eighth cranial nerve (auditory), 224

Eleventh cranial nerve (spinal accessory), 177, 225, 232

Epididymis, 216

Epiglottis, 207

Epiphyses of vertebræ, 185

Epiphysis cerebri, 222

Ethmoid bone, 180

Eustachian canal, 177, 239

- E**xternal auditory meatus, 174, 177; carotid artery, 199; jugular vein, 198, 201; nares, 174; rectus muscle, 237
- F**ACIAL nerve (seventh cranial), 177, 224, 231  
Fallopian tubes, 219  
Femoral artery, 213; vein, 213  
Femur, 193  
Fenestra ovalis, 240; rotunda, 240  
Fibula, 194  
Fifth nerve (trigeminal), 176, 177, 224, 230; nasal branch of, 178  
Filum terminale of spinal cord, 225  
Fissure, infraorbital, 177  
Flocculus, 222  
Foramen, condyloid, 177, 183; dental of lower jaw, 185; jugular, 177; lacerum anterius, 176, 178; lacerum posterius, 177; magnum, 183; mental, 185, 231; obturator, 193; of exit for the seventh nerve, 177; of Monro, 228; optic, 178, 182; ovale, 177; posterior palatine, 176; prepalatine, 176; rotundum, 176  
Foramina, intervertebral, 186; of exit of cranial nerves, 176, 177, 178  
Forelimb, 175; bones of, 191  
Fornix, 226, 228  
Fossa, orbito-temporal, 178; supra- and infra-spinous of scapula, 190  
Fourth cranial nerve (pathetic), 236, 244  
Frontal bones, 181
- G**ANGLION, Gasserian, 230; on the dorsal root of spinal nerves, 225  
General dissection, 196  
Genital nerve, 234  
Genito-urinary aperture, 175; organs of female, 219; of male, 215  
Glands, Cowper's, 218; lachrymal, 197, 236; lymphatic, of the neck, 197; mammary, 220; parotid, 197; preputial, 215; submaxillary, 197  
Gland, prostate, 218  
Glans penis, 215, 217  
Glenoid cavity, 190
- Glosso - pharyngeal nerve (ninth cranial), 177, 224, 232  
Glottis, 207  
Greater trochanter of the femur, 193; tuberosity of the humerus, 191  
Great omentum, 209
- H**AIR, 173  
Hairy pads of cheeks, 206  
Hallux, 195  
Hardening of brain and spinal cord, 226  
Hard palate, 206  
Harderian gland, 236  
Heart, 200; dissection of, 204  
Hemispheres, cerebral, 222  
Hepatic duct, 211, 214; veins, 212  
Hilus of kidney, 214  
Hind limb, 175; bones of, 193  
Hippocampus major, 227  
Horns of lateral ventricles of the brain, 226  
Hyoid bone, 185  
Hypoglossal nerve (twelfth cranial), 177, 183, 225, 232
- I**LEUM, 210  
Iliac veins, 212  
Ilium, 192  
Incisors, 196  
Incus, 240  
Inferior maxillary nerve, 230; mesenteric artery, 212; oblique muscle, 237; rectus muscle, 237  
Infraorbital fissure, 177  
Infundibulum, 223, 228  
Inguinal canal, 216  
Innominate artery, 202  
Intestine, large, 210; small, 209  
Intercondyloid notch of femur, 194  
Intercostal arteries, 203  
Interior of large intestine, 214; of small intestine, 213; of the stomach, 213  
Intermediale of carpus, 191; of tarsus, 194  
Internal jugular vein, 199; rectus muscle, 237  
Internasal cartilaginous septum, 181  
Interparietal bone, 183

Intervertebral foramina, 186  
 Iris, 238, 239  
 Ischium, 192, 193  
 Isthmus of the fauces, 206

**J** AW, lower, 184  
 Jejunum, 210  
 Jugal bone, 180

**K** IDNEYNS, 214

**L** ACHRYMAL bone, 180; canal, 174; gland, 236  
 Lamina terminalis, 228  
 Larynx, 207  
 Lateral ventricle of the brain, 226  
 Left anterior vena cava, 201; auricle of the heart, 201, 206; bronchus, 204; common iliac artery, 213; renal artery, 212; subclavian artery, 202; ventricle, 205, 206  
 Lens, 239  
 Length of intestine, 214  
 Lesser trochanter of femur, 193  
 Levator palpebræ muscle, 237  
 Lingual nerve, 231  
 Liver, 209  
 Lower jaw, 184  
 Lumbar enlargement of the spinal cord, 225  
 Lungs, 200  
 Lymphatic glands of the neck, 197

**M** ALLEOLI, 184  
 Malleus, 239  
 Mammary glands, 220  
 Manubrium of sternum, 190  
 Manus, 175  
 Meatus, external auditory, 174, 177  
 Median nerve, 233  
 Medulla oblongata, 223, 224, 227  
 Membrana nictitans, 174  
 Mental foramen, 185, 231  
 Mesenteric artery, 211  
 Mesentery, 211  
 Mesocolon, 211  
 Mesovarium, 219

Metacarpals, 192  
 Metapophyses of vertebrae, 188, 189  
 Metatarsal bones, 195  
 Middle ear, 207; sacral artery, 213  
 Molars, 196  
 Monroe, foramen of, 228  
 Mouth, 206; opening, 174  
 Muffle, 173  
 Muscles of the eyeball, 236, 237, 238; omo-hyoid, 199; pectoral, 196; sterno-cleido-mastoid, 198; sternohyoid, 199  
 Musculi papillares, 205; pectinati, 205, 206

**N** ARES, external, 174; posterior, 176, 207  
 Nasal bones, 178  
 Naso-pharynx, 207  
 Navicular bone, 195  
 Nerve, anterior crural, 213, 234; caudal, 235; circumflex, 233; eighth cranial (auditory), 224; eleventh cranial (spinal accessory), 177, 225, 232; fifth cranial (trigeminal), 176, 177, 224, 230; fourth cranial (patheticus), 224, 236; genital, 234; inferior maxillary, 230; lingual, 231; median, 233; nasal, 178, 238; ninth cranial (glosso-pharyngeal), 177, 224, 232; obturator, 234; olfactory, 229; ophthalmic, 230, 237; optic, 223, 230, 236, 238, 239; phrenic, 202, 233; pudic, 218, 219; radial, 233; recurrent laryngeal, 232; seventh cranial (facial), 177, 224, 231; sixth cranial (abducens), 224, 237; splanchnic, 235; superior laryngeal, 232; superior maxillary, 230; sympathetic, 199, 235; tenth cranial (pneumogastric), 177, 199, 224; third cranial (motor oculi), 224, 237; twelfth cranial (hypoglossal), 177, 183, 225, 232; ulnar, 233  
 Nerves, cervical, 233; coccygeal, 235; dorsal, 233; lumbar, 234; sacral, 233, 234; roots of spinal, 225  
 Neural arch, 185, 187, 188  
 Ninth cranial nerve (glosso-pharyngeal), 177, 224, 232

- O**BTURATOR foramen, 193; nerve, 234  
Occipital, bone, 183; condyles, 177, 183  
Odontoid process, 187  
Oesophagus, 204, 207  
Olecranon process, 191  
Olfactory lobes (rhinencephalon), 222, 223; nerves, 229  
Opening of the Eustachian tube, 207; of the urethra, 175; of the vagina, 175  
Openings of the cavæ with the right auricle, 205; of the pulmonary veins into the left auricle, 206; on the surface of the body, 174  
Ophthalmic nerve, 230, 237  
Optic commissure, 223; foramen, 178, 182; nerve, 223, 230, 236, 238, 239; thalami, 228  
Orbito-temporal fossa, 178  
Os pubis, 192; calcis, 194  
Os uteri, 220
- P**ALATE, hard, 206; soft, 207  
Pancreas, 211  
Parietal bones, 182  
Paroccipital processes, 183  
Parotid duct (Steno's), 197; gland, 197  
Patella, 194  
Pectoral muscles, 196  
Pedicle of vertebræ, 186  
Peduncles of the cerebellum, 223, 229  
Pelvis, bony, 192; of the kidney, 214  
Pelvic girdle, 192  
Penis, 174, 215; glans, 215, 217  
Pericardium, 200  
Periotic capsule, 184  
Peritoneum, 209  
Pes, 175  
Phalanges, 192  
Phrenic arteries, 212; nerve, 202, 233  
Pia mater, 222  
Pineal gland (epiphysis cerebri), 222  
Pinna, 174  
Pisiform bone, 192  
Pituitary body, 223  
Placenta, 221  
Pleura, 201
- Plexus, brachial, 225, 233; choroid, 229; sciatic, 225; solar, 235  
Pollex, 192  
Pons Varolii, 224, 227  
Portal vein, 211  
Posterior lacerated foramen, 177; mediastinum, 204; nares, 176, 207; palatine foramina, 176; peduncles of the cerebellum, 223, 229; tibial artery, 213; tibial nerve, 213, 234; vena cava, 202, 212  
Postzygapophyses, 186, 188  
Prefrontals, 181  
Premaxillæ, 178  
Prepalatine foramina, 176  
Preparation of skeleton, 175  
Prepuce, 175, 215  
Preputial glands, 215  
Presphenoid, 182  
Probe-pointed scissors, 204  
Process, acromion, 190; odontoid of axis, 187; olecranon, 191; spinous of vertebræ, 185, 187, 189; vermiciform of cerebellum, 222  
Processes, condyloid of lower jaw, 184; coronoid, 184; paroccipital, 183; pterygoid, 182; transverse of vertebræ, 185, 186, 187, 188, 189  
Prostate gland, 218  
Pterygoid processes, 182  
Pubis, 193  
Pudic nerve, 218, 219  
Pulmonary artery, 203; veins, 203  
Pylorus, 213
- R**ADIALE of carpus, 191  
Radial artery, 203; nerve, 233  
Radius, 191  
Rectum, 211  
Recurrent laryngeal nerves, 232  
Renal artery, 212, 214; veins, 212, 214  
Retina, 239  
Ribs, 189  
Right anterior vena cava, 198, 201; common iliac artery, 213; renal artery, 212; subclavian artery, 202, 203  
Root of spinal nerves, 225
- S**ACRAL nerves, 233, 234; vertebræ, 188  
Sagittal suture, 182

- S**cala tympani, 240  
 Scaphoid, 195  
 Scapula, 190  
 Sciatic nerve, 234; plexus, 225  
 Sclerotic, 238  
 Scrotum, 175  
 Semicircular canals, 240  
 Semilunar valves, 204, 205  
 Septum lucidum, 226; internasal cartilaginous, 181  
 Seventh cranial nerve (facial), 177, 224, 231  
 Shoulder girdle, 190  
 Sigmoid notch, 191  
 Sinuses of Valsalva, 204, 205  
 Sixth cranial nerve (abducens) 224, 237  
 Skeleton, bony and cartilaginous, 175  
 Skull, 176; base of, 176; side of, 177  
 Small intestine, 209  
 Solar plexus, 235  
 Spermatic artery, 212  
 Spermatozoa, 218  
 Sphenoid bone, 181  
 Spinal nerves, 233  
 Splanchnic nerves, 235; accessory nerve (eleventh cranial), 177, 225, 232  
 Spleen, 210  
 Squamosal bone, 183  
 Stapes, 240  
 Sternum, 190  
 Stomach, 210; interior of, 213  
 Subclavian artery, 202, 203; vein, 198, 201  
 Submaxillary duct (Wharton's), 197; glands, 197  
 Supra-renal capsule, 214  
 Superior laryngeal nerves, 232; maxillary nerve, 230; mesenteric artery, 211, 212; oblique muscle, 236; rectus muscle, 237  
 Suspensory ligament, 239  
 Suture, coronal, 182; sagittal, 184  
 Sympathetic nerve, 199, 235  
 Symphysis, menti, 184; pubis, 192, 193
- T**AIL, 193  
 Tænia hippocampi, 227; semicircularis, 227
- Tarsalia**, 195  
**Tarsus**, 194  
**Teats**, 175  
**Teeth**, 174  
**Tenth cranial nerve (pneumogastic)**, 177, 199, 224  
**Terminal epiphyses of vertebræ**, 185  
**Testicles**, 175, 216, 218  
**Thoracic cavity**, 199  
**Thymus body**, 200  
**Thyroid body**, 197; cartilages, 208  
**Tibia**, 194  
**Tibiale**, 194  
**Tongue**, 206  
**Trachea**, 204, 206  
 Transverse fissure of the brain, 229; ligament of atlas, 186; process of vertebræ, 185, 186, 187, 188, 189  
**Tricuspid valve**, 204  
**Trigeminal nerve (fifth cranial)**, 176, 177, 224, 230  
**Tuberculum of rib**, 189  
**Tuberosity, greater, of humerus**, 191  
**Tunica vaginalis of testicle**, 216  
**Twelfth cranial nerve (hypoglossal)**, 177, 183, 225, 232  
**Tympanic bone**, 184; bulla, 177; membrane, 239
- U**LNA, 191  
 Ulnar artery, 203; nerve, 233  
 Ulnare of carpus, 191  
 Umbilical cord, 221  
 Ureter, 214  
 Urethra, 218, 219  
 Uterus, 219
- V**AGINA, 219, 220  
 Valve, bicuspid, 205; of Vieussens, 222; semilunar, 204, 205; tricuspid, 204  
 Vas deferens, 217, 218  
 Vein, azygos, 202; external jugular, 198, 201; internal jugular, 199; portal, 211; subclavian, 198, 201  
 Veins, femoral, 213; hepatic, 212; iliac, 212; of heart walls, 204; renal, 212, 214; pulmonary, 203  
 Velum interpositum, 229

- Vena cava, anterior, 198, 201; left, 201; right, 201; posterior, 202, 212  
Ventricle, fourth of brain, 223; lateral of brain, 226; left of heart, 205, 206; right of heart, 204; third of brain, 226  
Vermiform process of the cerebellum, 222  
Vertebrae, caudal, 188; cervical, 185; dorsal, 187; lumbar, 188; sacral, 188  
Vertebral ribs, 189  
Vertebro-costal ribs, 189  
Vertebro-sternal ribs, 189  
Verumontanum, 217, 218
- Vesiculæ seminales, 217, 218  
Vestibule of the ear, 240  
Vibrissæ, 173  
Vitreous humor of the eye, 238  
Vocal cords, 207, 208  
Vomer, 180
- X IPHISTERNUM, 190
- Z YGAPOPHYSES, 186, 189  
Zygomatic arch, 178; process of squamosal, 183





